CLEAR LAKE STORMWATER TREATMENT SYSTEM PRELIMINARY DESIGN REPORT

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Submitted to:

City of LaPorte, Indiana
Parks and Recreation Department

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CLEAR LAKE
STORMWATER TREATMENT SYSTEM

PRELIMINARY DESIGN REPORT

1. **Treatment Goal**: Reduce annual phosphorus loadings to Clear Lake by 80% for the contributing watershed area for the 48-inch RCP stormsewer which discharges into the southwest corner of Clear Lake.

2. **Contributing Watershed**: Based on field investigation by ERD personnel in La Porte during a precipitation event, the area draining to the 48-inch RCP stormsewer was determined as shown in Figure 1. Generally, the watershed is bounded by Jefferson Avenue to the south, the railroad tracks to the north, Chicago Street to the west, and Detroit Street to the east. The contributing watershed area is 63.2 acres. The majority of the area is located in downtown La Porte, with a small area of adjacent single-family residential land use.

3. **Hydrologic Parameters**: Based on field investigation of the contributing watershed area, hydrologic parameters were developed for input into the Santa Barbara Urban Hydrograph (SBUH) model.

   The contributing watershed includes 57.3 acres (90.7%) of high-intensity commercial (downtown) and 5.9 acres (9.3%) of single-family residential land uses.

   The high-intensity commercial is 95% impervious with 90% directly connected impervious area (DCIA). The single-family residential is 27.8% impervious with 15.1% DCIA.

   A Hydrologic Soil Group (HSG) "C" was assigned to all pervious (grass) areas.

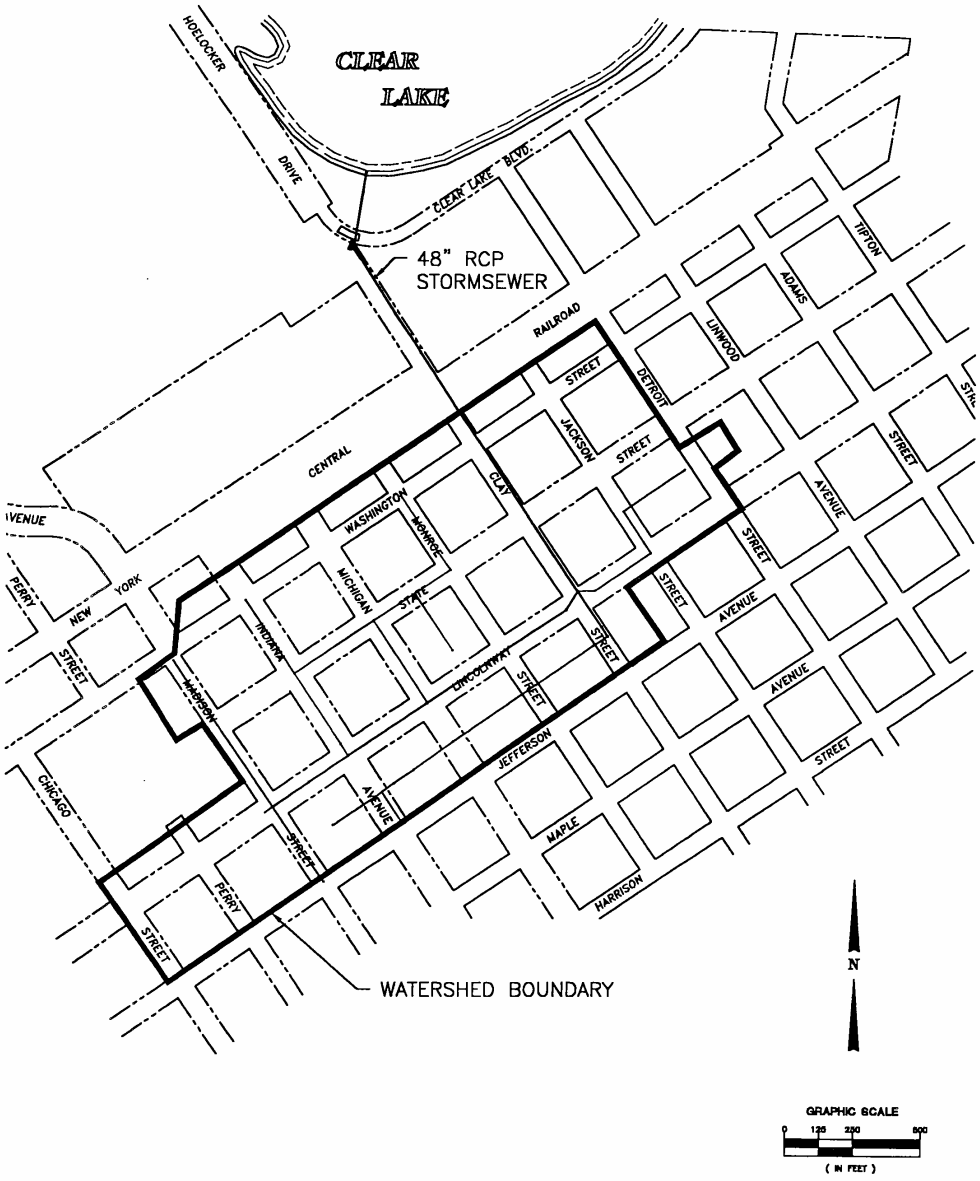
   The Time of Concentration (t_c) was calculated using the Kinematic Wave Equation for overland flow and flow calculations for pipe flow. Midwest region frequency-intensity-duration curves were used to determine the rainfall intensity. The detailed calculations are provided in Appendix A.

   A summary of hydrologic parameters is provided in Table 1.

TABLE 1

SUMMARY OF HYDROLOGIC PARAMETERS FOR STORMWATER RUNOFF MODELING FOR THE 48-INCH STORMSEWER DISCHARGING TO CLEAR LAKE

AREA (ac)	% LAKES	% DCIA	CN N-DCIA	t_c (min)	INITIAL ABSTRACTION DCIA (in)	INITIAL ABSTRACTION N-DCIA (dec)
63.2	0.0	83.0	84.0	23.5	0.05	0.20



ERD ENVIRONMENTAL RESEARCH AND DESIGN, INC.	CLEAR LAKE STORMWATER TREATMENT SYSTEM LaPorte, Indiana	WATERSHED DELINEATION	SCALE:	1"=500'
			FIG. NO.	1
			PROJ. NO.	97-001
			DRAWN BY:	LEH

4. **Rainfall Distribution**: EarthInfo NCDC hourly precipitation data from file TD-3240 of the National Climatic Data Center was used to develop a statistically average rainfall probability distribution for the City of La Porte, Indiana. A probability distribution was performed of individual rain events measured in La Porte during the period from 1979-1994. Hourly precipitation records were used to determine the rainfall volumes contributed by individual rain events during this time period. Events separated by three hours or more were considered to be separate rain events for purposes of this distribution. A total of 1864 rain events were evaluated over the 26-year period. During the record of evaluation, approximately 84% of all rain events were 0.5 inches or less, and 94% of all rain events were 1 inch or less.

The rain events were divided into 10 separate rain event intervals to categorize typical rainfall amounts for single rain events in the City of La Porte area. The 10 selected rain event intervals included: 0.0-0.10, 0.11-0.20, 0.21-0.30, 0.31-0.40, 0.41-0.50, 0.51-1.00, 1.01-1.50, 1.51-2.00, 2.01-2.50, and greater than 2.50 inches of rainfall. An interval point was selected for each of the 10 rain event ranges equal to the mean of the rainfall depth for each interval for use in modeling purposes. Finally, an event duration was assumed for each selected rain event range for use in hydrograph generation and estimation of discharge rates. A summary of the average annual rain event information is provided in Table 2.

TABLE 2

SUMMARY OF AVERAGE ANNUAL RAIN EVENT CHARACTERISTICS IN LA PORTE, INDIANA FROM 1979-1994

RAIN EVENT DEPTH RANGE (in)	MEAN OF RAINFALL DEPTH (in)	ASSUMED DURATION (hrs)	FRACTION OF ANNUAL RAIN EVENTS	NUMBER OF ANNUAL RAIN EVENTS	TOTAL ANNUAL RAINFALL (in)
0.00-0.10	0.08	1.0	0.483	56	4.48
0.11-0.20	0.17	4.0	0.164	19	3.23
0.21-0.30	0.28	4.0	0.086	10	2.80
0.31-0.40	0.38	4.0	0.069	8	3.04
0.41-0.50	0.47	4.0	0.043	5	2.35
0.51-1.00	0.73	8.0	0.095	11	8.03
1.01-1.50	1.25	8.0	0.034	4	5.00
1.51-2.00	1.70	8.0	0.009	1	1.70
2.01-2.50	2.21	24.0	0.009	1	2.21
> 2.50	3.25	24.0	0.009	1	3.25
				TOTAL:	36.09

5. **Estimated Annual Volume of Stormwater Runoff**: The Santa Barbara Urban Hydrograph (SBUH) method was used to generate estimates of rainfall runoff volumes produced for each of the 10 rain event intervals discussed previously. Summaries of the computer modeling printouts for each of the 10 rain event intervals used for estimation of runoff hydrographs and runoff volumes are provided in Appendix A.

Based on the estimates of runoff volumes generated from the computer modeling process, individual interval runoff coefficients were calculated by comparing computer estimates of the generated runoff depth with the corresponding rainfall depth used for modeling purposes within each interval. This procedure provides an estimation of individual runoff coefficients for each rain interval. Total runoff generated by rain events in a particular interval is obtained by multiplying the estimated runoff coefficient for the rainfall interval times the number of annual rain events occurring within a particular rainfall interval times the contributing watershed area. This procedure is a simplified version of a continuous simulation model for rain events over a prolonged period.

A summary of estimated runoff coefficients and runoff volumes for each of the 10 rain event intervals is provided in Table 3. For example, a 0.08-inch rainfall produces 0.02 inches of runoff for an event runoff "C" value of 0.25. The 56 annual rain events in this rain event interval generate a total of 5.9 ac-ft of runoff in a typical year. The total annual runoff volume for the contributing watershed of the 48-inch stormsewer discharging to the southwest corner of Clear Lake is 134.9 ac-ft, with an average weighted "C" value of 0.712.

TABLE 3

SUMMARY OF ESTIMATED ANNUAL RUNOFF VOLUME FOR THE 48-INCH STORMSEWER CONTRIBUTING WATERSHED IN LA PORTE, INDIANA

RAIN EVENT DEPTH RANGE (in)	MEAN OF RAINFALL DEPTH (in)	ASSUMED DURATION (hrs)	FRACTION OF ANNUAL RAIN EVENTS	NUMBER OF ANNUAL RAIN EVENTS	EVENT RUNOFF DEPTH (in)	EVENT RUNOFF "C" VALUE	ANNUAL RUNOFF VOLUME (ac-ft)
0.00-0.10	0.08	1.0	0.483	56	0.02	0.250	5.90
0.11-0.20	0.17	4.0	0.164	19	0.10	0.588	10.01
0.21-0.30	0.28	4.0	0.086	10	0.19	0.679	10.01
0.31-0.40	0.38	4.0	0.069	8	0.27	0.711	11.38
0.41-0.50	0.47	4.0	0.043	5	0.35	0.745	9.22
0.51-1.00	0.73	8.0	0.095	11	0.57	0.781	33.02
1.01-1.50	1.25	8.0	0.034	4	1.04	0.832	21.91
1.51-2.00	1.70	8.0	0.009	1	1.46	0.859	7.69
2.01-2.50	2.21	24.0	0.009	1	1.95	0.882	10.27
> 2.50	3.25	24.0	0.009	1	2.95	0.908	15.54
						Total:	134.9

Area = 63.2 acres

Weighted "C" Value: 0.712

6. Chemical Characteristics of Stormwater Runoff and Dry Weather Baseflow:

A. Chemical Characteristics of Stormwater Runoff: A stormwater monitoring program was conducted by ERD in the Clear Lake watershed from December 1996 to April 1997 to document the chemical characteristics of stormwater runoff and dry weather baseflow entering the lake. An automated Sigma sequential stormwater sampler with integral flow meter was installed by ERD in the 48-inch RCP stormsewer system near the intersection of State Street and Clay Street in January 1997. The automated sampler was programmed to collect samples of stormwater runoff and dry weather baseflow on a flow-weighted basis. Collected samples were retrieved by ERD field personnel within 24-48 hours following storm events and transported to the ERD research laboratory in Orlando, Florida for subsequent testing. A total of 9 separate composite stormwater runoff samples were collected during the period from December 1996 to April 1997. In addition, two separate composite dry weather baseflow samples were also collected, primarily as a result of snow melt events. Each of the collected stormwater runoff and baseflow samples were analyzed for nutrients, general inorganic parameters, demand parameters, microbiological parameters, and selected metals.

A summary of chemical characteristics of stormwater runoff samples collected in the Clear Lake drainage basin from December 1996 to April 1997 is given in Table 4. Stormwater runoff entering Clear Lake was found to be approximately neutral in pH, with a mean pH values of 7.44 and a range of values from 7.27-7.66. Specific conductivity in stormwater samples fluctuated widely between the individual monitoring events, with conductivity values ranging from 278-23,325 μmho/cm. However, runoff events with significantly elevated specific conductivity values are thought to have been influenced by roadway deicing agents. In general, stormwater runoff entering Clear Lake appears to be well buffered, with measured alkalinity values ranging from 65.5-275 mg/l. Measured alkalinity values for several of the monitored storm events may also have been influenced by the use of roadway deicing agents.

Stormwater runoff entering Clear Lake was found to contain relatively elevated levels of both total nitrogen and total phosphorus. Measured total nitrogen concentrations in stormwater runoff range from 2577-7552 μg/l, with an overall mean of 4746 μg/l. Approximately 57% of the mean total nitrogen is comprised of particulate nitrogen, which reflects nitrogen attached to both inorganic particles such as soil and organic particles such as vegetation. Dissolved organic nitrogen comprises approximately 11% of the total nitrogen measured, with 25% contributed by NO_x and 7% by ammonia. In general, a wide range of variability is apparent in measured concentrations of all nitrogen species between monitored storm events. A high degree of variability is also apparent in measured concentrations of total phosphorus in stormwater runoff, with values ranging from 20-764 μg/l, and an overall mean total phosphorus concentration of 355 μg/l. Approximately 91% of the total phosphorus is comprised of particulate phosphorus, with 8% as orthophosphorus.

A high degree of variability is apparent in measured concentrations of turbidity and TSS in stormwater runoff entering Clear Lake. Measured turbidity values in stormwater runoff range from 1.8-690 NTU, with an overall mean of 149 NTU. Suspended solids concentrations range from 16.2-797 mg/l, with an overall mean of 199 mg/l. Each of these values appears to be somewhat elevated compared with characteristics of stormwater runoff typically measured in urban areas.

TABLE 4

CHEMICAL CHARACTERISTICS OF STORMWATER RUNOFF SAMPLES COLLECTED IN CLEAR LAKE FROM DECEMBER 1996 - APRIL 1997

PARAMETER	UNITS	DATE									MEAN VALUE
		12/11/96	2/22/97	3/2/97	3/5/97	3/7/97	3/9/97	3/24-25/97	3/28-29/97	4/5/97	
pH	s.u.	7.66	7.29	7.64	7.50	7.27	7.33	7.59	7.32	7.36	7.44
Spec. Cond.	µmho/cm	278	481	22,041	1401	23,325	1378	2765	1541	616	5981
Alkalinity	mg/l	93.1	65.5	262	75.9	275	129	246	108	74.3	140
NH_3-N	µg/l	87	247	567	173	468	384	468	341	255	332
$NO_2 + NO_3$-N	µg/l	577	871	1695	958	2312	1478	1498	502	951	1205
Diss. Organic N	µg/l	58	513	1265	366	523	415	917	295	367	524
Particulate N	µg/l	5843	1824	491	2162	161	2185	4075	6414	1004	2684
Total N	µg/l	6565	3455	4018	3659	3464	4462	6958	7552	2577	4746
Diss. Ortho-P	µg/l	3	55	43	33	18	37	18	9	26	27
Particulate P	µg/l	512	184	47	193	12	404	625	750	176	323
Total P	µg/l	524	230	99	232	20	463	653	764	208	355
Turbidity	NTU	690	127	76.2	25.7	1.8	62.2	96.0	240	25.7	149
T.S.S.	mg/l	797	110	19.0	16.2	23.1	105	166	498	61.0	199
Chloride	mg/l	--	5.5	6.2	5.1	8587	203	495	11.5	2.5	1165
BOD	mg/l	17.6	3.9	133	25.1	0.5	7.3	8.7	35.5	20.5	28.0
Sulfate	mg/l	16.7	92	8507	264	175	42.2	70.2	388	76	1070
Diss. Aluminum	µg/l	16	49	34	15	22	12	26	18	21	24
Total Coliform	No./100 ml	300	900	150	120	8	14	440	960	396	365
Fecal Coliform	No./100 ml	200	400	120	60	6	8	320	870	344	259
Total Iron	µg/l	--	--	6	--	--	--	14	20	6	6

A high degree of variability is also apparent in measured concentrations of BOD and sulfate entering Clear Lake. In general, BOD concentrations in stormwater runoff appear to be somewhat elevated, with typical values ranging from 0.5-133 mg/l, with an overall mean of 28.0 mg/l. An even greater degree of variability is apparent for measured concentrations of sulfate, with values ranging from 42.2-8507 mg/l. Many of the highly elevated values for sulfate appear to be influence by roadway deicing agents.

In general, measured concentrations of total and fecal coliform bacteria in stormwater runoff entering Clear Lake appear to be relatively low in value compared with values typically measured in urban runoff. The overall mean fecal coliform bacteria of 259 organisms/100 ml and the mean total coliform concentration of 365 organisms/100 ml are approximately 10-100 times less than typical urban runoff values.

B. **Chemical Characteristics of Dry Weather Baseflow**: Chemical characteristics of dry weather baseflow samples collected in Clear Lake are summarized in Table 5. Each of the events represented in Table 5 are thought to have originated primarily as a result of snow melt events. Each of the monitored dry weather baseflow events are represented by a neutral pH value, with an overall mean pH of 7.19. Specific conductivity values in dry weather baseflow were found at extremely elevated levels, with an overall mean of 20,378 μmho/cm. Dry weather baseflow was also found to be extremely well buffered, with a mean alkalinity of 253 mg/l.

As seen in Table 5, dry weather baseflow was found to be relatively high in total nitrogen, with a mean total nitrogen concentration similar to that found in stormwater runoff. The dominant nitrogen species in dry weather baseflow appears to be NO_x, which represents approximately 54% of the total nitrogen measured. Particulate phosphorus was found to represent approximately 10% of the total nitrogen, with 18% contributed by dissolved organic nitrogen and 17% contributed by ammonia. In contrast to the results found with stormwater runoff, dry weather baseflow was found to be relatively low in total phosphorus, with an overall mean total phosphorus concentration of 34 μg/l.

Dry weather baseflow was also found to be low in turbidity and suspended solids, particularly when compared with stormwater runoff characteristics listed in Table 4. Dry weather baseflow was also found to contain extremely elevated levels of chloride, with a mean concentration of 12,282 mg/l, as well as sulfate, with a mean concentration of 161 mg/l. Measured BOD concentrations in dry weather baseflow were found at extremely low levels.

In general, dry weather baseflow was found to contain extremely low concentrations of both total and fecal coliform bacteria, with overall mean concentrations for these two parameters of 20 organisms/100 ml or less.

TABLE 5

CHEMICAL CHARACTERISTICS OF DRY WEATHER BASEFLOW SAMPLES COLLECTED IN CLEAR LAKE

PARAMETER	UNITS	DATE		MEAN VALUE
		3/5/97	3/20-4/3/97	
pH	s.u.	7.11	7.27	7.19
Spec. Cond.	µmho/cm	23,325	17,431	20,378
Alkalinity	mg/l	242	263	253
NH_3-N	µg/l	511	1114	813
NO_2 + NO_3-N	µg/l	2747	2475	2611
Diss. Organic N	µg/l	888	862	875
Particulate N	µg/l	678	318	498
Total N	µg/l	4824	4769	4797
Diss. Ortho-P	µg/l	2	2	2
Particulate P	µg/l	12	49	31
Total P	µg/l	15	53	34
Turbidity	NTU	0.8	4.6	2.7
T.S.S.	mg/l	109	36.3	72.8
Chloride	mg/l	14,376	10,187	12,282
BOD	mg/l	0.5	0.9	0.7
Sulfate	mg/l	176	145	161
Diss. Aluminum	µg/l	19	30	25
Total Coliform	No./100 ml	10	26	18
Fecal Coliform	No./100 ml	4	16	20
Total Iron	µg/l	--	< 6	< 6

7. **Evaluation of the Effectiveness of Aluminum Sulfate and Ferric Chloride for Treatment of Stormwater Runoff Entering Clear Lake**: A series of laboratory jar tests were conducted on runoff samples collected from the Clear Lake drainage basin to evaluate the effectiveness of alum and ferric chloride for reducing pollutant concentrations in stormwater runoff. Separate laboratory jar tests were conducted on six separate runoff samples using alum and four separate samples using ferric chloride. Each of the collected stormwater samples was treated with alum doses of 5, 7.5 and 10 mg/l as Al, with equivalent ferric chloride doses of 10, 15 and 20 mg/l as Fe. Since the molecular weight of iron is approximately twice that of aluminum, the laboratory doses were selected to provide approximately equivalent numbers of aluminum and iron molecules in the test containers to obtain the most accurate comparison of the effectiveness of each compound.

   Individual laboratory jar tests were conducted for each coagulant at each dose using a sample volume of approximately 2 liters or greater for each test. To begin each test, the appropriate amount of alum or ferric chloride was added to each container, and the stormwater mixture was vigorously agitated for approximately 60 seconds. The coagulated samples were then allowed to settle for a period of 24 hours, simulating settling processes which would occur within a detention or settling basin. At the end of the 24-hour settling period, the clear supernatant was decanted for laboratory analysis of stormwater parameters. Measurements of sample pH were conducted initially in the raw stormwater and in each treated sample at a time of 1 minute, 1 hour and 24 hours after the addition of the coagulant to document changes in pH which typically occur after the addition of chemical coagulants. In addition, a raw sample of runoff was allowed to settle for 24 hours without the addition of a chemical coagulant. This sample simulates removal efficiencies which would be achieved in a settling pond with a detention time of approximately 24 hours. This allows a comparison of removal efficiencies in chemical characteristics of stormwater runoff treated in a settling pond basin with and without the addition of chemical coagulants.

   While performing the laboratory testing, the pH of each treated sample was carefully monitored during the initial rapid mix period. If the pH of any treated sample fell below a value of 6.0 immediately after the addition of the chemical coagulant, a concentrated NaOH solution would be dripped into the container to maintain an equilibrium pH of 6.0. The volume of buffer solution added was recorded to provide an estimate of the amount of NaOH buffer which must be added to the sample to maintain a value of 6.0 in the treated effluent. This information is useful for the design process in evaluating the potential need for supplemental buffering compounds and the estimated addition rate for selection of appropriate chemical transfer equipment. A complete listing of laboratory results for the six stormwater samples coagulated with alum is given in Appendix B. A listing of laboratory results for the four stormwater samples coagulated with ferric chloride is given in Appendix C.

   A. **Effectiveness of Aluminum Sulfate**: Mean chemical characteristics of laboratory jar tests conducted with alum on stormwater runoff samples collected from the 48-inch RCP entering Clear Lake from December 1996 to April 1997 are given in Table 6. Information provided in this table reflects the mean of laboratory jar tests conducted on six separate stormwater runoff samples. In general, the addition of alum from the six runoff samples resulted in a slight decrease in pH, with mean pH values decreasing from 7.42 in the raw runoff samples to values of 6.77, 6.47 and 6.24, at alum doses of 5, 7.5 and 10 mg/l as Al, respectively, approximately 1 minute following the alum addition. Measured pH values gradually increased over a period of 24 hours, reaching equilibrium pH values of 7.38, 7.25 and 7.09 for alum doses of 5, 7.5 and 10 mg/l as Al,

respectively. As seen in Appendix B, none of the stormwater samples required the addition of the NaOH buffer to maintain a minimum pH value of 6.0 when coagulated with alum at a dose of 5 mg/l. When the dose is increased to 7.5 mg/l, only one of the six stormwater samples required the addition of the NaOH buffer to maintain the minimum 6.0 pH level. Similarly, only two of the six tested storm events required the addition of the NaOH buffer at a dose of 10 mg/l as Al. As seen in Table 6, it appears that an alum dose of approximately 7.5 mg/l or less could safely be added to stormwater runoff entering Clear Lake while maintaining a minimum pH level of approximately 6.5 or greater approximately one hour following the alum addition and an equilibrium pH of 7.25 or greater approximately 24 hours following the alum addition.

As seen in Table 6, addition of alum to stormwater runoff resulted in a slight decrease in alkalinity which increased with increasing alum dose. However, in spite of the alum addition, the treated stormwater samples remained well buffered with alkalinity values ranging from approximately 80-90 mg/l at an alum dose of 7.5 mg/l or less.

The addition of alum to stormwater runoff had relatively little effect on measured concentrations of ammonia, NO_x or dissolved organic nitrogen. Alum is not generally recognized for its ability to remove either inorganic or organic nitrogen species. However, the addition of alum to stormwater runoff did result in significant reductions in particulate nitrogen, reducing the mean initial particulate nitrogen concentration of 2379 μg/l to values of approximately 87 μg/l or less. The reduction in particulate nitrogen is primarily responsible for the relatively impressive removals of total nitrogen observed at each of the three tested alum doses. In contrast to the trends observed with nitrogen species, the addition of alum resulted in significant reductions in measured concentrations of all phosphorus species, with substantial concentration reductions observed for dissolved orthophosphorus, particulate phosphorus and total phosphorus. At an alum dose of 7.5 mg/l, the addition of alum reduced dissolved orthophosphorus concentrations from an initial value of 33 μg/l to 1 μg/l, particulate phosphorus from an initial value of 270 μg/l to 6 μg/l, and total phosphorus from an initial value of 307 μg/l to 10 μg/l. Alum coagulation of the stormwater runoff resulted in equilibrium phosphorus concentrations which are sufficiently low to restrict algal growth by phosphorus limitation.

Addition of alum to stormwater runoff was also observed to provide substantial reductions in concentrations of turbidity, suspended solids and BOD. The addition of alum reduced turbidity concentrations from a mean initial value of 99 NTU to approximately 3 NTU, with TSS reductions from 141 mg/l to 3 mg/l, and BOD reductions from 6.2 mg/l to 1.4 mg/l. Slight increases in sulfate concentrations were observed with increasing alum dose due to the dissociation of the aluminum sulfate molecules.

Extremely low levels of dissolved aluminum were observed at all tested doses. The highest mean dissolved aluminum concentration was observed at an alum dose of 7.5 mg/l, with an equilibrium concentration of 42 μg/l. This value reflects an extremely low dissolved aluminum concentration and is approximately half of the recommended EPA dissolved aluminum criterion of 87 μg/l.

The addition of alum to stormwater runoff resulted in a substantial reduction in measured concentrations of both total and fecal coliform bacteria. At an alum dose of 7.5 mg/l, total coliform concentrations were reduced from 505 organisms/100 ml to 12

TABLE 6

MEAN CHEMICAL CHARACTERISTICS OF LABORATORY JAR TESTS CONDUCTED WITH ALUM ON STORMWATER RUNOFF SAMPLES COLLECTED FROM THE 48-INCH RCP ENTERING CLEAR LAKE FROM DECEMBER 1996 TO APRIL 1997 (n = 6 tests)

PARAMETER	UNITS	COMPOSITE RAW	SETTLED WITHOUT ALUM	ALUM TREATED AND SETTLED FOR 24 HOURS (Dose in mg/l as Al)		
				5 mg/l	7.5 mg/l	10 mg/l
pH (initial)	s.u.	7.42	7.42	7.42	7.42	7.42
pH (1 minute)[1]	s.u.	7.42	7.42	6.77	6.47	6.24
pH (1 hour)[1]	s.u.	7.42	7.44	6.78	6.51	6.30
pH (24 hours)[1]	s.u.	7.41	7.47	7.38	7.25	7.09
Conductivity	µmho/cm	5216	5048	5288	5277	5369
Alkalinity	mg/l	117	109	90.1	82.6	74.7
NH_3-N	µg/l	317	264	293	286	314
NO_2 + NO_3-N	µg/l	995	904	928	966	934
Diss. Organic N	µg/l	561	799	666	647	747
Particulate N	µg/l	2379	302	87	71	38
Total N	µg/l	4252	2269	1974	1969	2028
Diss. Ortho-P	µg/l	33	21	2	1	1
Particulate P	µg/l	270	61	9	6	4
Total P	µg/l	307	84	13	10	9
Turbidity	NTU	99	14	3	2	2
TSS	mg/l	141	15.1	3.0	2.0	2.0
BOD	mg/l	6.2	3.6	1.4	1.4	1.2
Sulfate	mg/l	43.6	44.2	72.4	95.9	106.3
Chloride	mg/l	1865	1953	1954	2007	2135
Diss. Aluminum	µg/l	27	29	32	42	22
Total Coliform	No./100 ml	505	240	21	12	7
Fecal Coliform	No./100 ml	359	127	15	8	3
Total Iron	µg/l	8	8	7	11	4

1. Measured pH values at 1 minute, 1 hour and 24 hours following chemical additions.

organisms/100 ml in the treated sample. Similarly, fecal coliform concentrations were reduced from 359 organisms/100 ml to approximately 8 organisms/100 ml at a dose of 7.5 mg/l. Optimum reductions in chemical characteristics in laboratory jar tests appear to occur at an alum dose of approximately 7.5 mg/l. Although slightly lower concentrations can be achieved for certain parameters at higher alum doses, the small incremental improvement in water quality does not appear to be justified by the added chemical expense of injection at a higher dose.

Average percent change in chemical characteristics of laboratory jar tests conducted with alum on stormwater runoff samples is summarized in Table 7. At an alum dose of 7.5 mg/l, total nitrogen was reduced by approximately 48%, with total phosphorus reduced by 95%, turbidity by 96%, TSS by 95%, and BOD by 67%. Excellent removal efficiencies were observed for total and fecal coliform bacteria, with a 97% removal for total coliform and 98% removal for fecal coliform.

TABLE 7

MEAN PERCENT CHANGE IN CHEMICAL CHARACTERISTICS OF LABORATORY JAR TESTS CONDUCTED WITH ALUM ON STORMWATER RUNOFF SAMPLES COLLECTED FROM THE 48-INCH RCP ENTERING CLEAR LAKE FROM DECEMBER 1996 TO APRIL 1997 (n = 6 tests)

PARAMETER	UNITS	SETTLED WITHOUT ALUM	ALUM TREATED AND SETTLED FOR 24 HOURS (Dose in mg/l as Al)		
			5 mg/l	7.5 mg/l	10 mg/l
NH_3-N	µg/l	-15	-8	-8	1
NO_2 + NO_3-N	µg/l	-5	-3	1	-1
Diss. Organic N	µg/l	37	24	19	28
Particulate N	µg/l	-80	-92	-92	-96
Total N	µg/l	-41	-48	-48	-47
Diss. Ortho-P	µg/l	-34	-93	-94	-95
Particulate P	µg/l	-67	-95	-96	-97
Total P	µg/l	-62	-94	-95	-96
Turbidity	NTU	-82	-95	-96	-98
TSS	mg/l	-60	-93	-95	-96
BOD	mg/l	-33	-67	-67	-71
Total Coliform	No./100 ml	-41	-95	-97	-98
Fecal Coliform	No./100 ml	-48	-96	-98	-99

In summary, it appears that an alum dose of 7.5 mg/l can safely be added to stormwater runoff entering Clear Lake with no adverse affects on lake pH. Addition of alum into stormwater runoff as discussed will result in a removal efficiency of approximately 48% for total nitrogen, 95% for total phosphorus, 96% for turbidity, and 95% for TSS and 97-98% for coliform bacteria.

B. **Effectiveness of Ferric Chloride**: A summary of mean chemical characteristics of laboratory jar tests conducted using ferric chloride on stormwater runoff samples entering Clear Lake is given in Table 8. Values listed in this table reflect a mean of four separate jar test studies conducted on stormwater runoff. Similar to the trend observed with alum, addition of ferric chloride to stormwater runoff resulted in a decrease in overall pH of the treated sample. Maximum pH reduction was observed after 1 minute following the ferric chloride addition, with a gradual increase in pH over a period of 24 hours. Although initial pH values, measured 1 minute after ferric chloride addition, appear to be somewhat lower than those observed with alum, the equilibrium 24-hour pH values appear to be relatively similar for both chemicals. As seen in Appendix C, additions of NaOH buffer were not required for any test samples using ferric chloride to maintain a minimum pH value of 6.0 measured 1 minute after coagulant addition. Similar to the trends observed with alum, addition of ferric chloride resulted in a decrease in alkalinity within the treated samples which increased with increasing ferric chloride dose.

The addition of ferric chloride to stormwater samples resulted in little measurable change in measured concentrations of ammonia, NO_x or dissolved organic nitrogen. However, ferric chloride was quite effective in reducing concentrations of particulate nitrogen, although not to the extent observed with alum. The observed reductions in concentrations of total nitrogen results primarily from reductions in particulate nitrogen.

The addition of ferric chloride to runoff samples resulted in significant reductions in measured concentrations of all phosphorus species. At a ferric chloride dose of 5 mg/l, measured concentrations of dissolved orthophosphorus were decreased from a mean of 23 μg/l to 2 μg/l, with particulate phosphorus reduced from 373 μg/l to 7 μg/l, and total phosphorus reduced from 401 μg/l to 12 μg/l. In general, observed reductions in phosphorus species using ferric chloride are virtually identical to those achieved using alum.

The addition of ferric chloride to runoff samples resulted in substantial reductions in measured concentrations of turbidity, TSS and BOD, with equilibrium concentrations similar to those observed following alum coagulation.

The addition of ferric chloride was also affective in reducing measured concentrations of coliform bacteria. However, equilibrium coliform concentrations listed in Table 8 are substantially higher than equilibrium concentrations listed in Table 6 which were achieved using alum. It appears that ferric chloride exhibits a lower affinity for removal of bacteria than is typically observed when using alum. Similar to the trends observed with alum, addition of ferric chloride does not significantly affect the measured concentration of total iron within the sample.

A summary of mean percent change in chemical characteristics in laboratory jar tests using ferric chloride is given in Table 9. The addition of ferric chloride at a dose of 5 mg/l resulted in a mean removal for total nitrogen of approximately 57%, approximately 96% for total phosphorus, 95% for turbidity, 94% for TSS, 66% for BOD, and 82-85% for coliform bacteria. With the exception of coliform bacteria, removal efficiencies for ferric chloride listed in Table 9 are similar to those listed in Table 7 for alum.

TABLE 8

MEAN CHEMICAL CHARACTERISTICS OF LABORATORY JAR TESTS CONDUCTED WITH FERRIC CHLORIDE ON STORMWATER RUNOFF SAMPLES COLLECTED FROM THE 48-INCH RCP ENTERING CLEAR LAKE FROM DECEMBER 1996 TO APRIL 1997 (n = 4 tests)

PARAMETER	UNITS	COMPOSITE RAW	SETTLED WITHOUT FERRIC CHLORIDE	FERRIC CHLORIDE TREATED AND SETTLED FOR 24 HOURS (Dose in mg/l as Fe)		
				10 mg/l	15 mg/l	20 mg/l
pH (initial)	s.u.	7.39	7.39	7.39	7.39	7.39
pH (1 minute)[1]	s.u.	7.39	7.39	6.59	6.36	6.12
pH (1 hour)[1]	s.u.	7.42	7.44	6.62	6.40	6.15
pH (24 hours)[1]	s.u.	7.43	7.48	7.39	7.26	7.14
Conductivity	µmho/cm	1186	1188	1167	1183	1202
Alkalinity	mg/l	86.1	81.9	70.2	58.5	49.0
NH_3-N	µg/l	256	241	190	209	218
NO_2 + NO_3-N	µg/l	804	832	786	795	793
Diss. Organic N	µg/l	343	412	416	380	388
Particulate N	µg/l	3193	227	238	360	223
Total N	µg/l	4596	1712	1630	1743	1622
Diss. Ortho-P	µg/l	23	14	2	2	1
Particulate P	µg/l	373	71	7	6	4
Total P	µg/l	401	89	12	9	8
Turbidity	NTU	97.1	6.7	1.6	1.9	1.5
TSS	mg/l	192	13.4	3.0	2.3	2.0
BOD	mg/l	6.4	2.5	1.3	1.1	1.1
Sulfate	mg/l	27.0	24.9	27.0	26.3	26.3
Chloride	mg/l	243	245	224	235	255
Diss. Aluminum	mg/l	18	16	9	12	11
Total Coliform	No./100 ml	492	153	63	68	54
Fecal Coliform	No./100 ml	425	101	44	58	46
Total Iron	µg/l	13	13	16	10	47

1. Measured pH values at 1 minute, 1 hour and 24 hours following chemical additions.

TABLE 9

MEAN PERCENT CHANGE IN CHEMICAL CHARACTERISTICS OF LABORATORY JAR TESTS CONDUCTED WITH FERRIC CHLORIDE ON STORMWATER RUNOFF SAMPLES COLLECTED FROM THE 48-INCH RCP ENTERING CLEAR LAKE FROM DECEMBER 1996 TO APRIL 1997 (n = 6 tests)

PARAMETER	UNITS	SETTLED WITHOUT FERRIC CHLORIDE	FERRIC CHLORIDE TREATED AND SETTLED FOR 24 HOURS (Dose in mg/l as Fe)		
			10 mg/l	15 mg/l	20 mg/l
NH_3-N	µg/l	-11	-28	-23	-18
NO_2 + NO_3-N	µg/l	10	7	8	7
Diss. Organic N	µg/l	22	23	10	14
Particulate N	µg/l	-89	-84	-77	-84
Total N	µg/l	-56	-57	-53	-56
Diss. Ortho-P	µg/l	-34	-91	-92	-93
Particulate P	µg/l	-68	-97	-97	-98
Total P	µg/l	-66	-96	-97	-97
Turbidity	NTU	-85	-95	-95	-96
TSS	mg/l	-68	-94	-96	-97
BOD	mg/l	-44	-66	-67	-66
Total Coliform	No./100 ml	-55	-82	-81	-85
Fecal Coliform	No./100 ml	-66	-85	-82	-84

Based upon the results presented in Tables 8 and 9, it appears that a ferric chloride dose of 10-15 mg/l as Fe can be used to coagulate stormwater runoff entering Clear Lake. Equilibrium chemical characteristics at this dose will be virtually identical to those achieved by using alum. In view of the apparent similarities between the two compounds, it appears that either alum or iron can be used an acceptable coagulant for treating stormwater runoff entering Clear Lake. Therefore, selection of a coagulant should be based upon product price and convenience of use.

8. **Detention Time Calculations for the Existing Clear Lake Sedimentation Area**: In 1995, Harza Engineering Company designed a sediment trap for the 48-inch stormsewer pipe which discharges to the southwest corner of Clear Lake. The purpose of this sediment trap is to replace the existing trap which was failing. A secondary purpose of the trap is to capture floc resulting from the chemical treatment of stormwater in the 48-inch stormsewer. Based on a construction drawing of the sediment trap plan and sections provided by the City of La Porte dated December 13, 1995, the sediment trap bottom elevation is 793.0 and the top of the sediment trap is at elevation 798.0. By digitizing the 793 and 798 contours, it was determined that the surface area at elevation 793 is 0.50 acres and the surface area at elevation 798 is 0.86 acres. By multiplying the average area between the two contours times a 5-ft depth, it was determined that the sediment trap up to a normal water level of 798 has a volume of 3.4 ac-ft.

   Based on the Santa Barbara Urban Hydrograph modeling previously discussed, the peak discharge for the 1.25-inch, 8-hour storm event is 18.9 cfs. The peak discharge for the 1.50-inch, 8-hour storm event is 23.0 cfs. In Section 9, one of these design storms will be selected for the project. Based on a sediment trap normal water volume of 3.4 ac-ft, the detention time in the sediment trap for the peak discharge from the 1.25-inch, 8-hour storm event (18.9 cfs) is 2.2 hours. The detention time for the peak discharge from the 1.50-inch, 8-hour storm event (23 cfs) is 1.8 hours. Based on a total runoff volume of 5.5 ac-ft for a 1.25-inch, 8-hour storm event, the average detention time in the sediment trap is 5.9 hours. The 1.50-inch, 8-hour storm event results in a total runoff volume of 6.7 ac-ft. The average detention time for this storm is 4.9 hours. Since a longer detention time is preferred, it would be desirable to use the 1.25-inch, 8-hour storm event as the design storm event as long as the overall project objectives of providing an 80% reduction in the annual total phosphorus load from the 48-inch RCP stormsewer watershed can be achieved. The overall phosphorus load reduction will be discussed in the following section.

9. **Selection of Stormwater Chemical Treatment Design Criteria**: The chemical treatment system will be designed to treat up to the peak stormwater runoff discharge for the design storm event. The selection of a larger design storm event would result in treating more of the annual runoff volume from the watershed. For example, if the 1.25-inch, 8-hour storm event was selected as the design storm event, the chemical treatment system would be capable of adding the appropriate amount of chemical up to the peak discharge (18.9 cfs). For those storm events which have discharges greater than 18.9 cfs, the chemical treatment system would add the proper dose of chemical up to 18.9 cfs. Discharges in excess of 18.9 cfs would be treated with a lower chemical dose.

   A summary of treated annual runoff volumes for different design storms is provided in Table 10. The use of a 1.25-inch, 8-hour design storm event would result in the treatment of 117.9 ac-ft or about 87% of the total annual runoff volume. The selection of a 1.50-inch, 8-hour design storm event would result in 122.5 ac-ft of annual runoff volume being treated, or about 91% of the total annual runoff volume.

   The results of the laboratory jar testing with aluminum sulfate and ferric chloride, as discussed in Section 7, suggest that more than 93% of the total phosphorus contained in the stormwater runoff will be removed with an alum dose of 7.5 mg/l as Al or ferric chloride dose of 10-15 mg/l as Fe. The overall phosphorus load reduction is calculated by multiplying the percent of total annual runoff volume treated times the total phosphorus removal efficiency from the laboratory jar test results. Based on treating 87.4% of the total annual runoff volume using the 1.25-inch, 8-hour design storm event and the 93% total phosphorus removal efficiency from the laboratory jar tests, an annual total phosphorus load reduction of 81% can be achieved. The use of a 1.50-inch, 8-hour design storm event results in an annual total phosphorus load reduction of 84%.

TABLE 10

SUMMARY OF TREATED ANNUAL RUNOFF VOLUMES FOR DIFFERENT DESIGN STORMS

RAINFALL EVENT DEPTH RANGE (in)	MEAN OF RAINFALL DEPTH (in)	NUMBER OF ANNUAL RAIN EVENTS	EVENT RUNOFF DEPTH (in)	ANNUAL RUNOFF VOLUME (ac-ft)	RUNOFF VOLUME TREATED	
					1.25 in/8 hr DESIGN STORM (ac-ft)	1.50 in/8 hr DESIGN STORM (ac-ft)
0.00-0.10	0.08	56	0.02	5.90	5.90	5.90
0.11-0.20	0.17	19	0.10	10.01	10.01	10.01
0.21-0.30	0.28	10	0.19	10.01	10.01	10.01
0.31-0.40	0.38	8	0.27	11.38	11.38	11.38
0.41-0.50	0.47	5	0.35	9.22	9.22	9.22
0.51-1.00	0.73	11	0.57	33.02	33.02	33.02
1.01-1.50	1.25	4	1.04	21.91	16.99	16.99
1.51-2.00	1.70	1	1.46	7.69	5.48	5.48
2.01-2.50	2.21	1	1.95	10.27	5.48	6.68
> 2.50	3.25	1	2.95	15.54	5.48	6.68
			Totals:	134.9	117.9	122.5
					(87.4% of total annual runoff)	(90.8% of total annual runoff)

Area = 63.2 acres

The selection of a 1.25-inch, 8-hour design storm event provides the desired total phosphorus load reduction of 80%. In addition, the use of the lesser design storm results in a lower peak discharge, increases the detention time in the sediment trap, and requires the use of less chemical on an annual basis. For these reasons, the 1.25-inch, 8-hour design storm event is selected as the storm event that will be used to design the chemical treatment system. At an alum dose of 7.5 mg/l as Al, the chemical treatment system will need to have the capacity to add up to 1.1 gpm of aluminum sulfate. At a ferric chloride dose of 15 mg/l as Fe, the chemical treatment system will need to have a capacity of 0.7 gpm.

10. **Preliminary Chemical Treatment System Design:** The chemical stormwater treatment system proposed for Clear Lake will add liquid coagulant into the stormwater runoff on a flow-proportionate basis as it passes through the 48-inch RCP stormsewer upstream of the sediment trap. The preliminary engineering drawings for the chemical treatment system have been provided as a separate document from this report. The overall system plan for the chemical treatment system is provided on Drawing C-1, Sheet 3 of 6 of the preliminary engineering Drawings. Approximately 50 ft south of Clear Lake Drive a diagonal manhole will be constructed over the existing 48-inch RCP stormsewer. A hole will be cut in the top of the stormsewer so that a stormwater flow meter sensor can be mounted inside of the stormsewer. The stormwater flow meter sensor cable will be routed through 2-inch PVC conduit back to the equipment building located next to the existing manhole in the southwest corner of Clear Lake, directly adjacent to the 48-inch RCP stormsewer. The stormwater flow meter sensor will send a signal to the stormwater flow meter electronics in the equipment building. The stormwater flow meter electronics will provide a 4-20 mA signal which will operate the variable speed chemical feed pump. A stormwater flow of 0 cfs corresponds to no stormwater flow and no chemical being pumped. A 20 mA signal from the stormwater flow meter indicates a stormwater runoff flow of 18.9 cfs and will result in the chemical feed pump operating at 100% speed. A stroke adjustment will be used on the chemical feed pump so that a chemical dose of 7.5 mg/l as Al or 15 mg/l as Fe will be maintained over the range of stormwater flows from 0-18.9 cfs.

The chemical feed pump will be a positive displacement diaphragm type which will draw chemical from a 2500-gallon FRP storage tank located in the equipment building and will pump the chemical through a 1-inch PVC line and into the existing manhole in the southwest corner of Clear Lake. If ferric chloride is used, the tank size could be reduced to approximately 1600 gallons. To enhance the mixing between the stormwater runoff and the chemical in the 48-inch RCP stormsewer, air will be injected at the same point as the chemical with a positive displacement blower also located in the equipment building. A 2-inch PVC air line will be extended from the blower to the point of chemical and air addition.

The treated stormwater will then pass through the remaining portion of the 48-inch RCP stormsewer and discharge into the sediment trap located in the southwest corner of Clear Lake. The floc generated as a result of chemical treatment will settle in the sediment trap area for later collection. The equipment building could be precast concrete or concrete block built-in-place structure. A concrete driveway will connect the equipment building to Clear Lake Drive. Miscellaneous components located in the equipment building will include valves and piping, a chemical flow meter to measure the rate of chemical flow and the total amount of chemical used, a main electrical panel and wiring, a heater, and electrical outlets and lighting. Based on the results of the laboratory jar testing, the stormwater runoff did not require the addition of a buffering agent to maintain an acceptable pH in the stormwater runoff prior to discharge into Clear Lake. Fortunately, for this reason, there is no need for a pH monitoring or buffer feed system. In addition to the stormwater runoff having adequate alkalinity, the water in Clear Lake is also well buffered.

The treatment of 117.9 ac-ft of annual runoff volume with chemical will result in a chemical floc volume of approximately 0.24 ac-ft/yr. Based on a sediment trap [illegible] ac, this will result in an annual chemical floc accumulation of approximately [illegible] chemical floc will need to be removed from the sediment trap on a periodic basis [illegible] floc volume is small, it would be possible to remove floc from the trap only [illegible] per year. Due to the infrequent need to remove floc from the sediment trap, [illegible] automated chemical floc disposal system is not necessary. In addition, there is not adequate construction budget to construct an automated floc disposal system. The bottom area of the sediment trap is relatively flat at elevation 793 over a 0.5-ac area. Since the area for the floc will not accumulate in any one point and, therefore, it does seem beneficial to provide a single withdrawal

point in the sediment trap which could be used to remove floc. Based on the flat topography of the sediment trap bottom, it appears best to simply use a vactor truck or some other type of portable withdrawal system which would use a hose to vacuum floc from the sediment trap bottom. If floc removal was conducted twice per year, the approximate floc volume which would be removed each time is approximately 38,500 gallons. The actual volume of sediment in the sediment trap may be larger due to other solids entering the trap from stormwater runoff.

11. **Preliminary Opinion of Probable Construction Cost**: The Preliminary Opinion of Probable Construction Cost is $78,650. A breakdown of the costs are provided in Table 11. A 10% contingency has been included. This cost does not include providing electrical service to the building.

TABLE 11

CLEAR LAKE
STORMWATER TREATMENT SYSTEM
PRELIMINARY OPINION OF
PROBABLE CONSTRUCTION COST

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT COST ($)	TOTAL COST ($)
1.	1-inch PVC Chemical Feed Line, Fittings	LF	25	10.00	250.00
2.	1½-inch PVC Sensor Line, Fittings	LF	80	15.00	1,200.00
3.	2-inch PVC Air Line, Fittings	LF	35	15.00	525.00
4.	Connect PVC to Structure	EA	3	750.00	2,250.00
5.	Concrete Building	LS	--	--	20,000.00
6.	2500-gallon FRP Tank	EA	1	5,500.00	5,500.00
7.	Chemical Pump and Pump Controls	EA	1	17,500.00	17,500.00
8.	Blower	EA	1	1,000.00	1,000.00
9.	Chemical Meter	EA	1	1,000.00	1,000.00
10.	Stormwater Meter	EA	1	4,000.00	4,000.00
11.	Type P-7T Manhole (Modified)	EA	1	3,000.00	3,000.00
12.	Concrete Driveway	SY	14	50.00	700.00
13.	Sodding	SY	30	2.50	75.00
14.	Pump Building Piping, Fittings and Valves	LS	--	--	2,500.00
15.	1-inch Water Service	LS	--	--	1,000.00
16.	Electrical and Mechanical	LS	--	--	4,500.00
17.	Mobilization, Bonds, Permits, Insurance and Demobilization	LS	--	--	6,500.00
				Sub-Total:	$71,500.00
				10% Contingency:	7,150.00
				TOTAL:	**$78,650.00**

NOTE: Cost does not include providing electrical service to the building.

12. **Operation and Maintenance Requirements and Estimated Annual Cost**:

A. **Determination of Annual Chemical Requirement**: Per calculations provided in Item 8, a total annual runoff volume of approximately 117.9 ac-ft shall be treated with chemical. At an alum dose of 7.5 mg/l as Al, approximately 5300 gallons of alum would be required on an annual basis. At a ferric chloride dose of 15.0 mg/l as Fe, approximately 3200 gallons would be required.

B. **General Operation and Maintenance Requirements**: Once in operation, the chemical stormwater treatment system will require weekly visits by personnel to check system operation and to check the chemical tank level. Four man-hours should be allowed per week, or 208 man-hours per year. All equipment will be covered by a one-year warranty, as written into the Construction Specifications. In addition to normal operational visits, personnel will also need to occasionally pump out the sedimentation area so that the floc is not transferred into the lake during major storm events. Assuming chemical floc is removed from the sedimentation area an average of twice per year, an additional 16 man-hours (2 personnel for 8 hours) should be allowed per pumping event, for a total of 32 man-hours per year. The total labor requirement is, therefore, approximately 240 man-hours per year.

C. **Estimated Annual Cost**: The annual cost to operate and maintain the chemical stormwater treatment system for Clear Lake will include personnel, chemical, power, and renewal and replacement. Based on 240 man-hours per year and a wage rate of $15 per hour (which includes benefits), the annual labor cost would be approximately $3,600. At an alum cost of $0.52 per gallon, the required 5300 gallons of alum should cost approximately $2,756 per year. At a ferric chloride cost of $1.79 per gallon, the required 3200 gallons should cost approximately $5,728. Based on an average monthly power cost of $100, the estimated annual power cost is $1,200. The mechanical equipment in the equipment building has an anticipated useful life of approximately 20 years. Based on a present cost of $23,500 for the mechanical equipment, including the pump and controls, blower, chemical meter, and stormwater meter, and an anticipated 20-year useful life, the estimated annual renewal and replacement cost for the treatment system is $1,175. Therefore, the total estimated annual operation and maintenance cost for the Clear Lake Chemical Stormwater Treatment System is $8,731 for alum and $11,703 for ferric chloride.

13. **Permitting Requirements**: Based on conversations with Mr. Jim Ray of the Indiana Department of Natural Resources, no DNR Permit should be required for the Clear Lake stormwater treatment project. A permit from DNR would be required if construction were to occur in Clear Lake. At this time, no construction within the lake is anticipated. Mr. Ray indicated that an NPDES permit may be needed from the State of Indiana Department of Environmental Management (DEM). At the time this report was printed, ERD had contacted the DEM but had not received a response regarding the need for an NPDES permit for this project. ERD will continue to work with DEM to determine if an NPDES permit is required. If an NPDES permit is required, ERD will obtain the specific requirements for the permit application submittal.

APPENDICES

APPENDIX A

STORMWATER MODELING RESULTS

)ETERMINATION OF TIME OF CONCENTRATION

:ONVEYANCE CALCULATIONS :
.a. OVERLAND (<300 ft): KINEMATIC WAVE EQUATION
`c = 0.93*(L^0.6*N^0.6) / (i^0.4*S^0.3)
). OVERLAND (>300 ft) : VELOCITY CURVES
!. OPEN CHANNAL : MANNINGS EQUATION
/ = (1.49 / n) * R^.67 * S^.5
i. CONTINUITY EQUATION : Q = V * A

'ROJECT : CLEAR LAKE LA PORT, INDIANA
}ASIN No. : 1
\REA (ac) = 63.2

. OVERLAND FLOW

LENGTH	" N " VALUE	SLOPE	RAINFALL INTENSITY	STORM FREQUENCY	STORM DURATION		OVERLAND VELOCITY	TIME OF CONC. 1
(ft)		(ft / ft)	(in. / hr.)	(year)	(min)	(hour)	(ft / min.)	(min.)
50	0.4	0.005	4.8	10	15	---	---	14.7

SUB-TOTAL (min) = 14.7

!. OPEN CHANNEL FLOW
\SSUMPTIONS : RAINFALL INTENSITY (in / hr) = 3.0 (10 year freq. ,30 min. duration)
"C" VALUE = 0.7
Q(cfs) = iCA = 132.7 (RATIONAL METHOD)
PIPE DEPTH % = 0.5

PIPE SIZE / CULVERT	LENGTH	" N " VALUE	SLOPE	Rh	VELOCITY	TIME OF CONC. 2
(inches)	(ft)		(ft /ft)	(ft)	(ft / sec.)	(min.)
15	152	0.013	0.0014	0.31	1.96	1.3
24	708	0.013	0.0080	0.50	6.43	1.8
36	198	0.013	0.0010	0.75	2.98	1.1
48	1570	0.013	0.0025	1.00	5.72	4.6

SUB-TOTAL (min) = 8.8

TOTAL Tc (min.) = 23.5

:omments : Utilized Chicago, Illinois F-I-D curves to obtain intensity.

Reference : Open Channel Flow Module, Haestad Methods,1990

SANTA BARBARA URBAN HYDROGRAPH SB88119 VER 1.3

AR LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 0.08 INCH 1 HOUR STORM

many basins? --> 1
ılation Duration (hrs)--> 4
e Increment (mins) --> 1
ıt Interval --> 12
e Results? (Y/N) --> N

cify FILENAME containing INPUT DATA --> A:LAPORT.PAR

SANTA BARBARA URBAN HYDROGRAPH SB88119 VER 1.3

AR LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 0.08 INCH 1 HOUR STORM

IN NODE	AREA	% LAKE	% DCIA	CN	TC	INI AB DCIA	INI AB N-DCIA
) #	(acres)			N-DCIA	(min)	(ins)	(dec)
1 99	63.2	0.0	83.0	84.0	23.5	0.05	0.20

***** RAINFALL INPUT SECTION *****

s Curve or Actual Rainfall? (M/A) --> M

1 SCS TYPE II - 24 Hour Distribution
2 SCS TYPE II (Fla. Modified) - 24 Hour
3 SCS TYPE III - 24 Hour Distribution
4 OC 10 Year 6 Hour Storm (5.25 inches)
5 OC 25 Year 6 Hour Storm (5.75 inches)
6 OC 10 Year 24 Hour Storm (7.50 inches)
7 OC 25 Year 24 Hour Storm (8.60 inches)
8 FDOT 1 Hour Duration Mass Curve
9 FDOT 2 Hour Duration Mass Curve
10 FDOT 4 Hour Duration Mass Curve
11 FDOT 8 Hour Duration Mass Curve
12 FDOT 24 Hour Duration Mass Curve
13 FDOT 3 Day (72 hour) Duration Mass Curve
14 FDOT 7 Day (168 hour) Duration Mass Curve
15 FDOT 10 Day (240 hour) Duration Mass Curve
16 SFWMD 72 Hour Distribution
17 Midwest Region Mass Curve (1-6 hours)
18 Midwest Region Mass Curve (6.1-12 hours)
19 Midwest Region Mass Curve (12.1-24 hours)
20 Midwest Region Mass Curve (>24 hours)

Specify CURVE TYPE = 17

rm Duration (hrs) --> 1
al Rainfall (inches) --> .08

SANTA BARBARA URBAN HYDROGRAPH SB88119 VER 1.3
) Copyright 1983, Peter J. Singhofen, P.E.

AR LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 0.08 INCH 1 HOUR STORM

TIME (hrs)	RAIN (ins)	BASIN 1
.000	0.000	0.0
.200	0.042	0.0
.400	0.060	1.1
.600	0.069	1.6
.800	0.075	1.6
.000	0.080	1.5
.200	0.080	0.9
.400	0.080	0.5
.600	0.080	0.3
.800	0.080	0.2
.000	0.080	0.1
.200	0.080	0.1
.400	0.080	0.0
.600	0.080	0.0
.800	0.080	0.0
.000	0.080	0.0
.200	0.080	0.0
.400	0.080	0.0
.600	0.080	0.0
.800	0.080	0.0
.000	0.080	0.0

SANTA BARBARA URBAN HYDROGRAPH SB88119 VER 1.3
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AR LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 0.08 INCH 1 HOUR STORM

RUNOFF SUMMARY ***

IN ID# -->	1
VOL (cfs-hrs)	2
VOL (ac-ft)	0.1
VOL (inches)	0.02
K FLOW (cfs)	1.6
K TIME (hrs)	0.850

ANTA BARBARA URBAN HYDROGRAPH SB88119 VER 1.3

R LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 0.17 INCH 4 HOUR STORM

many basins? --> 1
lation Duration (hrs)--> 6
Increment (mins) --> 1
t Interval --> 12
Results? (Y/N) --> N

ify FILENAME containing INPUT DATA --> A:LAPORT.PAR

SANTA BARBARA URBAN HYDROGRAPH SB88119 VER 1.3

AR LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 0.17 INCH 4 HOUR STORM

IN NODE #	AREA (acres)	% LAKE	% DCIA	CN N-DCIA	TC (min)	INI AB DCIA (ins)	INI AB N-DCIA (dec)
1 99	63.2	0.0	83.0	84.0	23.5	0.05	0.20

***** RAINFALL INPUT SECTION *****

; Curve or Actual Rainfall? (M/A) --> M

1 SCS TYPE II - 24 Hour Distribution
2 SCS TYPE II (Fla. Modified) - 24 Hour
3 SCS TYPE III - 24 Hour Distribution
4 OC 10 Year 6 Hour Storm (5.25 inches)
5 OC 25 Year 6 Hour Storm (5.75 inches)
6 OC 10 Year 24 Hour Storm (7.50 inches)
7 OC 25 Year 24 Hour Storm (8.60 inches)
8 FDOT 1 Hour Duration Mass Curve
9 FDOT 2 Hour Duration Mass Curve
10 FDOT 4 Hour Duration Mass Curve
11 FDOT 8 Hour Duration Mass Curve
12 FDOT 24 Hour Duration Mass Curve
13 FDOT 3 Day (72 hour) Duration Mass Curve
14 FDOT 7 Day (168 hour) Duration Mass Curve
15 FDOT 10 Day (240 hour) Duration Mass Curve
16 SFWMD 72 Hour Distribution
17 Midwest Region Mass Curve (1-6 hours)
18 Midwest Region Mass Curve (6.1-12 hours)
19 Midwest Region Mass Curve (12.1-24 hours)
20 Midwest Region Mass Curve (>24 hours)

Specify CURVE TYPE = 17

rm Duration (hrs) --> 4
al Rainfall (inches) --> .17

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AR LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 0.17 INCH 4 HOUR STORM

TIME (hrs)	RAIN (ins)	BASIN 1
.000	0.000	0.0
.200	0.027	0.0
.400	0.056	0.6
.600	0.073	2.2
.800	0.088	3.0
.000	0.102	3.2
.200	0.112	3.0
.400	0.121	2.7
.600	0.127	2.4
.800	0.134	2.1
.000	0.139	1.8
.200	0.143	1.5
.400	0.146	1.2
.600	0.150	1.1
.800	0.153	1.0
.000	0.156	1.0
.200	0.160	0.9
.400	0.163	0.9
.600	0.165	0.7
.800	0.167	0.6
.000	0.170	0.7
.200	0.170	0.4
.400	0.170	0.3
.600	0.170	0.2
.800	0.170	0.1
.000	0.170	0.1
.200	0.170	0.0
.400	0.170	0.0
.600	0.170	0.0
.800	0.170	0.0
.000	0.170	0.0

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AR LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 0.17 INCH 4 HOUR STORM

RUNOFF SUMMARY ***

IN ID# --> 1

VOL (cfs-hrs) 6
VOL (ac-ft) 0.5
VOL (inches) 0.10

K FLOW (cfs) 3.2
K TIME (hrs) 1.000

SANTA BARBARA URBAN HYDROGRAPH SB88119 VER 1.3

AR LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 0.28 INCH 4 HOUR STORM

```
 many basins?          -->  1
ulation Duration (hrs)-->  8
e Increment (mins)     -->  1
nt Interval            -->  12
e Results? (Y/N)       -->  N

cify FILENAME containing INPUT DATA                --> A:LAPORT.PAR
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SANTA BARBARA URBAN HYDROGRAPH SB88119 VER 1.3

AR LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 0.28 INCH 4 HOUR STORM

IN D	NODE #	AREA (acres)	% LAKE	% DCIA	CN N-DCIA	TC (min)	INI AB DCIA (ins)	INI AB N-DCIA (dec)
1	99	63.2	0.0	83.0	84.0	23.5	0.05	0.20

***** RAINFALL INPUT SECTION *****

s Curve or Actual Rainfall? (M/A) --> M

1 SCS TYPE II - 24 Hour Distribution
2 SCS TYPE II (Fla. Modified) - 24 Hour
3 SCS TYPE III - 24 Hour Distribution
4 OC 10 Year 6 Hour Storm (5.25 inches)
5 OC 25 Year 6 Hour Storm (5.75 inches)
6 OC 10 Year 24 Hour Storm (7.50 inches)
7 OC 25 Year 24 Hour Storm (8.60 inches)
8 FDOT 1 Hour Duration Mass Curve
9 FDOT 2 Hour Duration Mass Curve
10 FDOT 4 Hour Duration Mass Curve
11 FDOT 8 Hour Duration Mass Curve
12 FDOT 24 Hour Duration Mass Curve
13 FDOT 3 Day (72 hour) Duration Mass Curve
14 FDOT 7 Day (168 hour) Duration Mass Curve
15 FDOT 10 Day (240 hour) Duration Mass Curve
16 SFWMD 72 Hour Distribution
17 Midwest Region Mass Curve (1-6 hours)
18 Midwest Region Mass Curve (6.1-12 hours)
19 Midwest Region Mass Curve (12.1-24 hours)
20 Midwest Region Mass Curve (>24 hours)

Specify CURVE TYPE = 17

rm Duration (hrs) --> 4
al Rainfall (inches) --> .28

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AR LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 0.28 INCH 4 HOUR STORM

TIME hrs)	RAIN (ins)	BASIN 1
.000	0.000	0.0
.200	0.045	0.0
.400	0.092	4.4
.600	0.120	5.7
.800	0.146	6.1
.000	0.168	6.0
.200	0.185	5.4
.400	0.199	4.7
.600	0.210	4.0
.800	0.221	3.6
.000	0.230	3.1
.200	0.235	2.4
.400	0.241	2.1
.600	0.246	1.8
.800	0.252	1.7
.000	0.258	1.6
.200	0.263	1.6
.400	0.269	1.5
.600	0.272	1.2
.800	0.274	1.0
.000	0.280	1.2
.200	0.280	0.7
.400	0.280	0.4
.600	0.280	0.3
.800	0.280	0.2
.000	0.280	0.1
.200	0.280	0.1
.400	0.280	0.0
.600	0.280	0.0
.800	0.280	0.0
.000	0.280	0.0
.200	0.280	0.0
.400	0.280	0.0
.600	0.280	0.0
.800	0.280	0.0
.000	0.280	0.0
.200	0.280	0.0
.400	0.280	0.0
.600	0.280	0.0
.800	0.280	0.0
.000	0.280	0.0

SANTA BARBARA URBAN HYDROGRAPH SB88119 VER 1.3

AR LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 0.28 INCH 4 HOUR STORM

RUNOFF SUMMARY ***

IN ID# -->	1
VOL (cfs-hrs)	12
VOL (ac-ft)	1.0
VOL (inches)	0.19
K FLOW (cfs)	6.1
K TIME (hrs)	0.817

```
SANTA BARBARA URBAN HYDROGRAPH     SB88119    VER 1.3

AR LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 0.38 INCH 4 HOUR STORM


 many basins?           -->  1
ılation Duration (hrs)-->  10
e Increment (mins)      -->  1
nt Interval             -->  24
e Results? (Y/N)        -->  N

cify FILENAME containing INPUT DATA                --> A:LAPORT.PAR
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SANTA BARBARA URBAN HYDROGRAPH SB88119 VER 1.3

AR LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 0.38 INCH 4 HOUR STORM

IN D	NODE #	AREA (acres)	% LAKE	% DCIA	CN N-DCIA	TC (min)	INI AB DCIA (ins)	INI AB N-DCIA (dec)
1	99	63.2	0.0	83.0	84.0	23.5	0.05	0.20

***** RAINFALL INPUT SECTION *****

s Curve or Actual Rainfall? (M/A) --> M

1 SCS TYPE II - 24 Hour Distribution
2 SCS TYPE II (Fla. Modified) - 24 Hour
3 SCS TYPE III - 24 Hour Distribution
4 OC 10 Year 6 Hour Storm (5.25 inches)
5 OC 25 Year 6 Hour Storm (5.75 inches)
6 OC 10 Year 24 Hour Storm (7.50 inches)
7 OC 25 Year 24 Hour Storm (8.60 inches)
8 FDOT 1 Hour Duration Mass Curve
9 FDOT 2 Hour Duration Mass Curve
10 FDOT 4 Hour Duration Mass Curve
11 FDOT 8 Hour Duration Mass Curve
12 FDOT 24 Hour Duration Mass Curve
13 FDOT 3 Day (72 hour) Duration Mass Curve
14 FDOT 7 Day (168 hour) Duration Mass Curve
15 FDOT 10 Day (240 hour) Duration Mass Curve
16 SFWMD 72 Hour Distribution
17 Midwest Region Mass Curve (1-6 hours)
18 Midwest Region Mass Curve (6.1-12 hours)
19 Midwest Region Mass Curve (12.1-24 hours)
20 Midwest Region Mass Curve (>24 hours)

Specify CURVE TYPE = 17

rm Duration (hrs) --> 4
al Rainfall (inches) --> .38

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AR LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 0.38 INCH 4 HOUR STORM

TIME (hrs)	RAIN (ins)	BASIN 1
.000	0.000	0.0
.400	0.125	7.5
.800	0.198	8.8
.200	0.251	7.5
.600	0.285	5.5
.000	0.312	4.2
.400	0.327	2.8
.800	0.342	2.3
.200	0.357	2.1
.600	0.369	1.7
.000	0.380	1.6
.400	0.380	0.6
.800	0.380	0.2
.200	0.380	0.1
.600	0.380	0.0
.000	0.380	0.0
.400	0.380	0.0
.800	0.380	0.0
.200	0.380	0.0
.600	0.380	0.0
.000	0.380	0.0
.400	0.380	0.0
.800	0.380	0.0
.200	0.380	0.0
.600	0.380	0.0
.000	0.380	0.0

SANTA BARBARA URBAN HYDROGRAPH SB88119 VER 1.3

AR LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 0.38 INCH 4 HOUR STORM

RUNOFF SUMMARY ***

IN ID# -->	1
VOL (cfs-hrs)	17
VOL (ac-ft)	1.4
VOL (inches)	0.27
K FLOW (cfs)	8.8
K TIME (hrs)	0.800

```
;ANTA BARBARA URBAN HYDROGRAPH    SB88119   VER 1.3

.R LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 0.47 INCH 4 HOUR STORM


 many basins?          -->  1
.lation Duration (hrs)-->  10
: Increment (mins)     -->  1
.t Interval            -->  24
: Results? (Y/N)       -->  N

:ify FILENAME containing INPUT DATA              --> A:LAPORT.PAR
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;ANTA BARBARA URBAN HYDROGRAPH SB88119 VER 1.3

;R LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 0.47 INCH 4 HOUR STORM

;N)	NODE #	AREA (acres)	% LAKE	% DCIA	CN N-DCIA	TC (min)	INI AB DCIA (ins)	INI AB N-DCIA (dec)
1	99	63.2	0.0	83.0	84.0	23.5	0.05	0.20

***** RAINFALL INPUT SECTION *****

; Curve or Actual Rainfall? (M/A) --> M

1 SCS TYPE II - 24 Hour Distribution
2 SCS TYPE II (Fla. Modified) - 24 Hour
3 SCS TYPE III - 24 Hour Distribution
4 OC 10 Year 6 Hour Storm (5.25 inches)
5 OC 25 Year 6 Hour Storm (5.75 inches)
6 OC 10 Year 24 Hour Storm (7.50 inches)
7 OC 25 Year 24 Hour Storm (8.60 inches)
8 FDOT 1 Hour Duration Mass Curve
9 FDOT 2 Hour Duration Mass Curve
10 FDOT 4 Hour Duration Mass Curve
11 FDOT 8 Hour Duration Mass Curve
12 FDOT 24 Hour Duration Mass Curve
13 FDOT 3 Day (72 hour) Duration Mass Curve
14 FDOT 7 Day (168 hour) Duration Mass Curve
15 FDOT 10 Day (240 hour) Duration Mass Curve
16 SFWMD 72 Hour Distribution
17 Midwest Region Mass Curve (1-6 hours)
18 Midwest Region Mass Curve (6.1-12 hours)
19 Midwest Region Mass Curve (12.1-24 hours)
20 Midwest Region Mass Curve (>24 hours)

Specify CURVE TYPE = 17

;m Duration (hrs) --> 4
;l Rainfall (inches) --> .47

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AR LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 0.47 INCH 4 HOUR STORM

TIME (hrs)	RAIN (ins)	BASIN 1
.000	0.000	0.0
.400	0.155	10.1
.800	0.244	11.2
.200	0.310	9.4
.600	0.352	6.9
.000	0.385	5.2
.400	0.404	3.5
.800	0.423	2.9
.200	0.442	2.6
.600	0.456	2.1
.000	0.470	2.0
.400	0.470	0.8
.800	0.470	0.3
.200	0.470	0.1
.600	0.470	0.0
.000	0.470	0.0
.400	0.470	0.0
.800	0.470	0.0
.200	0.470	0.0
.600	0.470	0.0
.000	0.470	0.0
.400	0.470	0.0
.800	0.470	0.0
.200	0.470	0.0
.600	0.470	0.0
.000	0.470	0.0

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AR LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 0.47 INCH 4 HOUR STORM

RUNOFF SUMMARY ***

IN ID# --> 1

VOL (cfs-hrs) 22
VOL (ac-ft) 1.8
VOL (inches) 0.35

K FLOW (cfs) 11.2
K TIME (hrs) 0.800

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SANTA BARBARA URBAN HYDROGRAPH    SB88119   VER 1.3

AR LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 0.73 INCH 8 HOUR STORM


 many basins?          -->  1
ılation Duration (hrs)-->  14
: Increment (mins)     -->  1
ıt Interval            -->  24
: Results? (Y/N)       -->  N

:ify FILENAME containing INPUT DATA              --> A:LAPORT.PAR
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SANTA BARBARA URBAN HYDROGRAPH SB88119 VER 1.3

AR LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 0.73 INCH 8 HOUR STORM

IN D	NODE #	AREA (acres)	% LAKE	% DCIA	CN N-DCIA	TC (min)	INI AB DCIA (ins)	INI AB N-DCIA (dec)
1	99	63.2	0.0	83.0	84.0	23.5	0.05	0.20

***** RAINFALL INPUT SECTION *****

s Curve or Actual Rainfall? (M/A) --> M

1 SCS TYPE II - 24 Hour Distribution
2 SCS TYPE II (Fla. Modified) - 24 Hour
3 SCS TYPE III - 24 Hour Distribution
4 OC 10 Year 6 Hour Storm (5.25 inches)
5 OC 25 Year 6 Hour Storm (5.75 inches)
6 OC 10 Year 24 Hour Storm (7.50 inches)
7 OC 25 Year 24 Hour Storm (8.60 inches)
8 FDOT 1 Hour Duration Mass Curve
9 FDOT 2 Hour Duration Mass Curve
10 FDOT 4 Hour Duration Mass Curve
11 FDOT 8 Hour Duration Mass Curve
12 FDOT 24 Hour Duration Mass Curve
13 FDOT 3 Day (72 hour) Duration Mass Curve
14 FDOT 7 Day (168 hour) Duration Mass Curve
15 FDOT 10 Day (240 hour) Duration Mass Curve
16 SFWMD 72 Hour Distribution
17 Midwest Region Mass Curve (1-6 hours)
18 Midwest Region Mass Curve (6.1-12 hours)
19 Midwest Region Mass Curve (12.1-24 hours)
20 Midwest Region Mass Curve (>24 hours)

Specify CURVE TYPE = 18

rm Duration (hrs) --> 8
al Rainfall (inches) --> .73

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AR LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 0.73 INCH 8 HOUR STORM

TIME hrs)	RAIN (ins)	BASIN 1
.000	0.000	0.0
.400	0.022	0.0
.800	0.058	0.9
.200	0.088	2.8
.600	0.117	3.5
.000	0.161	4.9
.400	0.212	6.1
.800	0.285	8.3
.200	0.372	10.4
.600	0.453	10.6
.000	0.511	8.9
.400	0.555	7.0
.800	0.591	5.7
.200	0.621	4.6
.600	0.642	3.6
.000	0.664	3.2
.400	0.679	2.5
.800	0.694	2.2
.200	0.708	2.1
.600	0.715	1.4
.000	0.730	1.8
.400	0.730	0.7
.800	0.730	0.2
.200	0.730	0.1
.600	0.730	0.0
.000	0.730	0.0
.400	0.730	0.0
.800	0.730	0.0
.200	0.730	0.0
.600	0.730	0.0
.000	0.730	0.0
.400	0.730	0.0
.800	0.730	0.0
.200	0.730	0.0
.600	0.730	0.0
.000	0.730	0.0

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AR LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 0.73 INCH 8 HOUR STORM

RUNOFF SUMMARY ***

IN ID# -->	1
VOL (cfs-hrs)	37
VOL (ac-ft)	3.0
VOL (inches)	0.57
K FLOW (cfs)	10.6
K TIME (hrs)	3.600

SANTA BARBARA URBAN HYDROGRAPH SB88119 VER 1.3

AR LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 1.25 INCH 8 HOUR STORM

many basins? --> 1
ılation Duration (hrs)--> 16
ə Increment (mins) --> 1
ıt Interval --> 24
ə Results? (Y/N) --> N

ɔify FILENAME containing INPUT DATA --> A:LAPORT.PAR

SANTA BARBARA URBAN HYDROGRAPH SB88119 VER 1.3

AR LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 1.25 INCH 8 HOUR STORM

IN ID	NODE #	AREA (acres)	% LAKE	% DCIA	CN N-DCIA	TC (min)	INI AB DCIA (ins)	INI AB N-DCIA (dec)
1	99	63.2	0.0	83.0	84.0	23.5	0.05	0.20

***** RAINFALL INPUT SECTION *****

s Curve or Actual Rainfall? (M/A) --> M

1 SCS TYPE II - 24 Hour Distribution
2 SCS TYPE II (Fla. Modified) - 24 Hour
3 SCS TYPE III - 24 Hour Distribution
4 OC 10 Year 6 Hour Storm (5.25 inches)
5 OC 25 Year 6 Hour Storm (5.75 inches)
6 OC 10 Year 24 Hour Storm (7.50 inches)
7 OC 25 Year 24 Hour Storm (8.60 inches)
8 FDOT 1 Hour Duration Mass Curve
9 FDOT 2 Hour Duration Mass Curve
10 FDOT 4 Hour Duration Mass Curve
11 FDOT 8 Hour Duration Mass Curve
12 FDOT 24 Hour Duration Mass Curve
13 FDOT 3 Day (72 hour) Duration Mass Curve
14 FDOT 7 Day (168 hour) Duration Mass Curve
15 FDOT 10 Day (240 hour) Duration Mass Curve
16 SFWMD 72 Hour Distribution
17 Midwest Region Mass Curve (1-6 hours)
18 Midwest Region Mass Curve (6.1-12 hours)
19 Midwest Region Mass Curve (12.1-24 hours)
20 Midwest Region Mass Curve (>24 hours)

Specify CURVE TYPE = 18

rm Duration (hrs) --> 8
al Rainfall (inches) --> 1.25

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AR LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 1.25 INCH 8 HOUR STORM

TIME (hrs)	RAIN (ins)	BASIN 1
.000	0.000	0.0
.400	0.038	0.0
.800	0.100	4.5
.200	0.150	5.9
.600	0.200	6.3
.000	0.275	8.6
.400	0.362	10.5
.800	0.487	14.4
.200	0.637	18.3
.600	0.775	18.9
.000	0.875	15.9
.400	0.950	12.6
.800	1.013	10.3
.200	1.063	8.3
.600	1.100	6.5
.000	1.138	5.8
.400	1.163	4.4
.800	1.188	3.9
.200	1.213	3.8
.600	1.225	2.5
.000	1.250	3.2
.400	1.250	1.2
.800	1.250	0.4
.200	1.250	0.2
.600	1.250	0.1
.000	1.250	0.0
.400	1.250	0.0
.800	1.250	0.0
.200	1.250	0.0
.600	1.250	0.0
.000	1.250	0.0
.400	1.250	0.0
.800	1.250	0.0
.200	1.250	0.0
.600	1.250	0.0
.000	1.250	0.0
.400	1.250	0.0
.800	1.250	0.0
.200	1.250	0.0
.600	1.250	0.0
.000	1.250	0.0

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AR LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 1.25 INCH 8 HOUR STORM

RUNOFF SUMMARY ***

IN ID# --> 1

VOL (cfs-hrs) 66
VOL (ac-ft) 5.5
VOL (inches) 1.04

K FLOW (cfs) 18.9
K TIME (hrs) 3.600

SANTA BARBARA URBAN HYDROGRAPH SB88119 VER 1.3

AR LAKE IN LAPORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 1.50 INCH 8 HOUR STORM

many basins? --> 1
ılation Duration (hrs)--> 16
e Increment (mins) --> 1
nt Interval --> 24
e Results? (Y/N) --> N

cify FILENAME containing INPUT DATA --> A:LAPORT.PAR

SANTA BARBARA URBAN HYDROGRAPH SB88119 VER 1.3

AR LAKE IN LAPORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 1.50 INCH 8 HOUR STORM

IN D	NODE #	AREA (acres)	% LAKE	% DCIA	CN N-DCIA	TC (min)	INI AB DCIA (ins)	INI AB N-DCIA (dec)
1	99	63.2	0.0	83.0	84.0	23.5	0.05	0.20

***** RAINFALL INPUT SECTION *****

s Curve or Actual Rainfall? (M/A) --> M

1 SCS TYPE II - 24 Hour Distribution
2 SCS TYPE II (Fla. Modified) - 24 Hour
3 SCS TYPE III - 24 Hour Distribution
4 OC 10 Year 6 Hour Storm (5.25 inches)
5 OC 25 Year 6 Hour Storm (5.75 inches)
6 OC 10 Year 24 Hour Storm (7.50 inches)
7 OC 25 Year 24 Hour Storm (8.60 inches)
8 FDOT 1 Hour Duration Mass Curve
9 FDOT 2 Hour Duration Mass Curve
10 FDOT 4 Hour Duration Mass Curve
11 FDOT 8 Hour Duration Mass Curve
12 FDOT 24 Hour Duration Mass Curve
13 FDOT 3 Day (72 hour) Duration Mass Curve
14 FDOT 7 Day (168 hour) Duration Mass Curve
15 FDOT 10 Day (240 hour) Duration Mass Curve
16 SFWMD 72 Hour Distribution
17 Midwest Region Mass Curve (1-6 hours)
18 Midwest Region Mass Curve (6.1-12 hours)
19 Midwest Region Mass Curve (12.1-24 hours)
20 Midwest Region Mass Curve (>24 hours)

Specify CURVE TYPE = 18

rm Duration (hrs) --> 8
al Rainfall (inches) --> 1.5

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AR LAKE IN LAPORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 1.50 INCH 8 HOUR STORM

TIME hrs)	RAIN (ins)	BASIN 1
.000	0.000	0.0
.400	0.045	0.0
.800	0.120	6.0
.200	0.180	7.3
.600	0.240	7.7
.000	0.330	10.4
.400	0.435	12.6
.800	0.585	17.5
.200	0.765	22.3
.600	0.930	23.0
.000	1.050	19.4
.400	1.140	15.4
.800	1.215	12.6
.200	1.275	10.2
.600	1.320	7.9
.000	1.365	7.1
.400	1.395	5.4
.800	1.425	4.8
.200	1.455	4.6
.600	1.470	3.1
.000	1.500	3.9
.400	1.500	1.5
.800	1.500	0.5
.200	1.500	0.2
.600	1.500	0.1
.000	1.500	0.0
.400	1.500	0.0
.800	1.500	0.0
.200	1.500	0.0
.600	1.500	0.0
.000	1.500	0.0
.400	1.500	0.0
.800	1.500	0.0
.200	1.500	0.0
.600	1.500	0.0
.000	1.500	0.0
.400	1.500	0.0
.800	1.500	0.0
.200	1.500	0.0
.600	1.500	0.0
.000	1.500	0.0

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AR LAKE IN LAPORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 1.50 INCH 8 HOUR STORM

RUNOFF SUMMARY ***

IN ID# -->	1
VOL (cfs-hrs)	81
VOL (ac-ft)	6.7
VOL (inches)	1.27
K FLOW (cfs)	23.0
K TIME (hrs)	3.600

SANTA BARBARA URBAN HYDROGRAPH SB88119 VER 1.3

AR LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 1.70 INCH 8 HOUR STORM

many basins? --> 1
ulation Duration (hrs)--> 16
e Increment (mins) --> 1
nt Interval --> 24
e Results? (Y/N) --> N

cify FILENAME containing INPUT DATA --> A:LAPORT.PAR

SANTA BARBARA URBAN HYDROGRAPH SB88119 VER 1.3

AR LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 1.70 INCH 8 HOUR STORM

IN D	NODE #	AREA (acres)	% LAKE	% DCIA	CN N-DCIA	TC (min)	INI AB DCIA (ins)	INI AB N-DCIA (dec)
1	99	63.2	0.0	83.0	84.0	23.5	0.05	0.20

***** RAINFALL INPUT SECTION *****

s Curve or Actual Rainfall? (M/A) --> M

1 SCS TYPE II - 24 Hour Distribution
2 SCS TYPE II (Fla. Modified) - 24 Hour
3 SCS TYPE III - 24 Hour Distribution
4 OC 10 Year 6 Hour Storm (5.25 inches)
5 OC 25 Year 6 Hour Storm (5.75 inches)
6 OC 10 Year 24 Hour Storm (7.50 inches)
7 OC 25 Year 24 Hour Storm (8.60 inches)
8 FDOT 1 Hour Duration Mass Curve
9 FDOT 2 Hour Duration Mass Curve
10 FDOT 4 Hour Duration Mass Curve
11 FDOT 8 Hour Duration Mass Curve
12 FDOT 24 Hour Duration Mass Curve
13 FDOT 3 Day (72 hour) Duration Mass Curve
14 FDOT 7 Day (168 hour) Duration Mass Curve
15 FDOT 10 Day (240 hour) Duration Mass Curve
16 SFWMD 72 Hour Distribution
17 Midwest Region Mass Curve (1-6 hours)
18 Midwest Region Mass Curve (6.1-12 hours)
19 Midwest Region Mass Curve (12.1-24 hours)
20 Midwest Region Mass Curve (>24 hours)

Specify CURVE TYPE = 18

rm Duration (hrs) --> 8
al Rainfall (inches) --> 1.7

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AR LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 1.70 INCH 8 HOUR STORM

TIME hrs)	RAIN (ins)	BASIN 1
.000	0.000	0.0
.400	0.051	0.1
.800	0.136	7.2
.200	0.204	8.3
.600	0.272	8.8
.000	0.374	11.8
.400	0.493	14.4
.800	0.663	20.1
.200	0.867	25.6
.600	1.054	26.4
.000	1.190	22.2
.400	1.292	17.6
.800	1.377	14.4
.200	1.445	11.6
.600	1.496	9.1
.000	1.547	8.1
.400	1.581	6.2
.800	1.615	5.5
.200	1.649	5.2
.600	1.666	3.5
.000	1.700	4.5
.400	1.700	1.7
.800	1.700	0.6
.200	1.700	0.2
.600	1.700	0.1
.000	1.700	0.0
.400	1.700	0.0
.800	1.700	0.0
.200	1.700	0.0
.600	1.700	0.0
.000	1.700	0.0
.400	1.700	0.0
.800	1.700	0.0
.200	1.700	0.0
.600	1.700	0.0
.000	1.700	0.0
.400	1.700	0.0
.800	1.700	0.0
.200	1.700	0.0
.600	1.700	0.0
.000	1.700	0.0

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AR LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 1.70 INCH 8 HOUR STORM

RUNOFF SUMMARY ***

IN ID# -->	1
VOL (cfs-hrs)	93
VOL (ac-ft)	7.7
VOL (inches)	1.46
K FLOW (cfs)	26.4
K TIME (hrs)	3.600

```
SANTA BARBARA URBAN HYDROGRAPH     SB88119    VER 1.3

AR LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 2.21 INCH 24 HOUR STOR


 many basins?          -->  1
ulation Duration (hrs)-->  36
e Increment (mins)     -->  1
nt Interval            -->  30
e Results? (Y/N)       -->  N

cify FILENAME containing INPUT DATA                --> A:LAPORT.PAR
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SANTA BARBARA URBAN HYDROGRAPH SB88119 VER 1.3

AR LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 2.21 INCH 24 HOUR STOR

IN D	NODE #	AREA (acres)	% LAKE	% DCIA	CN N-DCIA	TC (min)	INI AB DCIA (ins)	INI AB N-DCIA (dec)
1	99	63.2	0.0	83.0	84.0	23.5	0.05	0.20

***** RAINFALL INPUT SECTION *****

s Curve or Actual Rainfall? (M/A) --> M

1 SCS TYPE II - 24 Hour Distribution
2 SCS TYPE II (Fla. Modified) - 24 Hour
3 SCS TYPE III - 24 Hour Distribution
4 OC 10 Year 6 Hour Storm (5.25 inches)
5 OC 25 Year 6 Hour Storm (5.75 inches)
6 OC 10 Year 24 Hour Storm (7.50 inches)
7 OC 25 Year 24 Hour Storm (8.60 inches)
8 FDOT 1 Hour Duration Mass Curve
9 FDOT 2 Hour Duration Mass Curve
10 FDOT 4 Hour Duration Mass Curve
11 FDOT 8 Hour Duration Mass Curve
12 FDOT 24 Hour Duration Mass Curve
13 FDOT 3 Day (72 hour) Duration Mass Curve
14 FDOT 7 Day (168 hour) Duration Mass Curve
15 FDOT 10 Day (240 hour) Duration Mass Curve
16 SFWMD 72 Hour Distribution
17 Midwest Region Mass Curve (1-6 hours)
18 Midwest Region Mass Curve (6.1-12 hours)
19 Midwest Region Mass Curve (12.1-24 hours)
20 Midwest Region Mass Curve (>24 hours)

Specify CURVE TYPE = 19

rm Duration (hrs) --> 24
al Rainfall (inches) --> 2.21

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AR LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 2.21 INCH 24 HOUR STOR

TIME hrs)	RAIN (ins)	BASIN 1
.000	0.000	0.0
.500	0.028	0.0
.000	0.055	0.6
.500	0.083	2.3
.000	0.110	2.7
.500	0.138	2.9
.000	0.166	2.9
.500	0.193	2.9
.000	0.221	2.9
.500	0.249	2.9
.000	0.276	2.9
.500	0.304	2.9
.000	0.332	2.9
.500	0.368	3.6
.000	0.405	3.8
.500	0.442	3.9
.000	0.479	3.9
.500	0.516	4.0
.000	0.553	4.0
.500	0.589	4.0
.000	0.634	4.7
.500	0.680	5.0
.000	0.729	5.5
.500	0.785	6.0
.000	0.840	6.2
.500	0.904	7.0
.000	0.969	7.3
.500	1.061	10.2
.000	1.171	12.1
.500	1.284	12.9
.000	1.403	13.8
.500	1.523	14.1
.000	1.613	11.4
.500	1.696	10.3
.000	1.768	8.8
.500	1.823	7.2
.000	1.878	6.8
.500	1.915	5.1
.000	1.952	4.6
.500	1.983	3.9
.000	2.011	3.5
.500	2.039	3.4
.000	2.066	3.4
.500	2.094	3.4
.000	2.114	2.6
.500	2.133	2.4
.000	2.155	2.7
.500	2.182	3.2
.000	2.210	3.3

SANTA BARBARA URBAN HYDROGRAPH   SB88119   VER 1.3

AR LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 2.21 INCH 24 HOUR STOR

TIME hrs)	RAIN (ins)	BASIN 1
.500	2.210	0.9
.000	2.210	0.3
.500	2.210	0.1
.000	2.210	0.0
.500	2.210	0.0
.000	2.210	0.0
.500	2.210	0.0
.000	2.210	0.0
.500	2.210	0.0
.000	2.210	0.0
.500	2.210	0.0
.000	2.210	0.0
.500	2.210	0.0
.000	2.210	0.0
.500	2.210	0.0
.000	2.210	0.0
.500	2.210	0.0
.000	2.210	0.0
.500	2.210	0.0
.000	2.210	0.0
.500	2.210	0.0
.000	2.210	0.0
.500	2.210	0.0
.000	2.210	0.0

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\R LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 2.21 INCH 24 HOUR STOR

RUNOFF SUMMARY ***

:N ID# --> 1

'OL (cfs-hrs) 124
'OL (ac-ft) 10.2
'OL (inches) 1.95

{ FLOW (cfs) 14.1
{ TIME (hrs) 15.600

```
:ANTA BARBARA URBAN HYDROGRAPH     SB88119    VER 1.3

.R LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 3.25 INCH 24 HOUR STOR


 many basins?          -->  1
.lation Duration (hrs)-->  36
: Increment (mins)     -->  1
.t Interval            -->  30
: Results? (Y/N)       -->  N

:ify FILENAME containing INPUT DATA                --> A:LAPORT.PAR
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SANTA BARBARA URBAN HYDROGRAPH SB88119 VER 1.3

AR LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 3.25 INCH 24 HOUR STOR

CN	NODE #	AREA (acres)	% LAKE	% DCIA	CN N-DCIA	TC (min)	INI AB DCIA (ins)	INI AB N-DCIA (dec)
1	99	63.2	0.0	83.0	84.0	23.5	0.05	0.20

***** RAINFALL INPUT SECTION *****

s Curve or Actual Rainfall? (M/A) --> M

1 SCS TYPE II - 24 Hour Distribution
2 SCS TYPE II (Fla. Modified) - 24 Hour
3 SCS TYPE III - 24 Hour Distribution
4 OC 10 Year 6 Hour Storm (5.25 inches)
5 OC 25 Year 6 Hour Storm (5.75 inches)
6 OC 10 Year 24 Hour Storm (7.50 inches)
7 OC 25 Year 24 Hour Storm (8.60 inches)
8 FDOT 1 Hour Duration Mass Curve
9 FDOT 2 Hour Duration Mass Curve
10 FDOT 4 Hour Duration Mass Curve
11 FDOT 8 Hour Duration Mass Curve
12 FDOT 24 Hour Duration Mass Curve
13 FDOT 3 Day (72 hour) Duration Mass Curve
14 FDOT 7 Day (168 hour) Duration Mass Curve
15 FDOT 10 Day (240 hour) Duration Mass Curve
16 SFWMD 72 Hour Distribution
17 Midwest Region Mass Curve (1-6 hours)
18 Midwest Region Mass Curve (6.1-12 hours)
19 Midwest Region Mass Curve (12.1-24 hours)
20 Midwest Region Mass Curve (>24 hours)

Specify CURVE TYPE = 19

rm Duration (hrs) --> 24
al Rainfall (inches) --> 3.25

ANTA BARBARA URBAN HYDROGRAPH SB88119 VER 1.3

R LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 3.25 INCH 24 HOUR STOR

IME (rs)	RAIN (ins)	BASIN 1
000	0.000	0.0
500	0.041	0.0
000	0.081	2.7
500	0.122	3.8
000	0.162	4.2
500	0.203	4.3
000	0.244	4.3
500	0.284	4.3
000	0.325	4.3
500	0.366	4.3
000	0.406	4.3
500	0.447	4.3
000	0.488	4.4
500	0.542	5.5
000	0.596	5.8
500	0.650	5.9
000	0.704	6.0
500	0.758	6.1
000	0.813	6.1
500	0.867	6.1
000	0.932	7.1
500	0.999	7.6
000	1.073	8.4
500	1.154	9.1
000	1.235	9.4
500	1.330	10.6
000	1.425	11.0
500	1.560	15.4
000	1.722	18.3
500	1.888	19.6
000	2.064	20.8
500	2.240	21.3
000	2.372	17.2
500	2.494	15.6
000	2.600	13.2
500	2.681	10.9
000	2.762	10.2
500	2.817	7.7
000	2.871	7.0
500	2.917	5.9
000	2.957	5.3
500	2.998	5.1
000	3.039	5.0
500	3.079	5.0
000	3.109	4.0
500	3.136	3.5
000	3.169	4.1
500	3.209	4.8
000	3.250	5.0

SANTA BARBARA URBAN HYDROGRAPH   SB88119   VER 1.3

AR LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 3.25 INCH 24 HOUR STOR

TIME (hrs)	RAIN (ins)	BASIN 1
.500	3.250	1.4
.000	3.250	0.4
.500	3.250	0.1
.000	3.250	0.0
.500	3.250	0.0
.000	3.250	0.0
.500	3.250	0.0
.000	3.250	0.0
.500	3.250	0.0
.000	3.250	0.0
.500	3.250	0.0
.000	3.250	0.0
.500	3.250	0.0
.000	3.250	0.0
.500	3.250	0.0
.000	3.250	0.0
.500	3.250	0.0
.000	3.250	0.0
.500	3.250	0.0
.000	3.250	0.0
.500	3.250	0.0
.000	3.250	0.0
.500	3.250	0.0
.000	3.250	0.0

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AR LAKE IN LA PORT INDIANA SUB-BASIN HYDROGRAPHS FOR A 3.25 INCH 24 HOUR STOR

RUNOFF SUMMARY ***

IN ID# --> 1

VOL (cfs-hrs) 188
VOL (ac-ft) 15.5
VOL (inches) 2.95

K FLOW (cfs) 21.3
K TIME (hrs) 15.600

APPENDIX B

RESULTS OF LABORATORY TESTING TO EVALUATE THE EFFECTIVENESS OF ALUM FOR TREATMENT OF STORMWATER RUNOFF ENTERING CLEAR LAKE

RESULTS OF LABORATORY JAR TESTS CONDUCTED ON STORMWATER RUNOFF SAMPLES COLLECTED FROM THE 42-INCH RCP ENTERING CLEAR LAKE ON DECEMBER 11, 1996

PARAMETER	UNITS	COMPOSITE RAW	SETTLED WITHOUT ALUM	ALUM TREATED AND SETTLED FOR 24 HOURS (Dose in mg/l as Al)		
				5 mg/l	7.5 mg/l	10 mg/l
pH (initial)	s.u.	7.66	7.66	7.66	7.66	7.66
pH (1 minute)[1]	s.u.	7.66	7.66	6.31	6.03	6.22
pH (1 hour)[1]	s.u.	7.60	7.58	6.28	6.18	6.24
pH (24 hours)[1]	s.u.	7.52	7.12	6.83	6.71	6.69
Conductivity	µmho/cm	278	233	254	261	281
Alkalinity	mg/l	93.1	48.9	31.2	29.5	32.5
NH_3-N	µg/l	87	30	124	150	146
NO_2 + NO_3-N	µg/l	577	524	409	472	496
Diss. Organic N	µg/l	58	75	38	35	30
Particulate N	µg/l	5843	860	130	36	50
Total N	µg/l	6565	1489	701	693	722
Diss. Ortho-P	µg/l	3	1	< 1	< 1	< 1
Particulate P	µg/l	512	68	4	1	1
Total P	µg/l	524	75	8	7	6
Turbidity	NTU	690	70.2	1.5	1.4	1.0
TSS	mg/l	797	40.7	2.7	2.0	1.3
BOD	mg/l	17.6	2.2	2.0	1.5	1.3
Sulfate	mg/l	16.7	18.8	34.4	54.2	64.8
Diss. Aluminum	mg/l	16	26	33	23	22
Total Coliform	No./100 ml	300	40	< 2	< 2	< 2
Fecal Coliform	No./100 ml	200	24	< 2	< 2	< 2
NaOH Buffer Added	mg/l	--	--	0.0	2.0	15.5

1. Measured pH values at 1 minute, 1 hour and 24 hours following chemical additions.

RESULTS OF LABORATORY JAR TESTS CONDUCTED ON STORMWATER RUNOFF SAMPLES COLLECTED FROM THE 42-INCH RCP ENTERING CLEAR LAKE ON FEBRUARY 22, 1997

PARAMETER	UNITS	COMPOSITE RAW	SETTLED WITHOUT ALUM	ALUM TREATED AND SETTLED FOR 24 HOURS (Dose in mg/l as Al)		
				5 mg/l	7.5 mg/l	10 mg/l
pH (initial)	s.u.	7.29	7.29	7.29	7.29	7.29
pH (1 minute)[1]	s.u.	7.29	7.29	6.77	6.26	6.03
pH (1 hour)[1]	s.u.	7.22	7.28	6.82	6.35	6.15
pH (24 hours)[1]	s.u.	7.20	7.29	7.01	6.75	6.64
Conductivity	µmho/cm	481	496	516	532	543
Alkalinity	mg/l	65.5	65.0	41.6	32.5	25.4
NH_3-N	µg/l	247	244	295	313	314
NO_2 + NO_3-N	µg/l	871	448	525	763	611
Diss. Organic N	µg/l	513	884	811	570	785
Particulate N	µg/l	1824	677	79	56	< 30
Total N	µg/l	3455	2253	1710	1702	1725
Diss. Ortho-P	µg/l	55	39	1	1	1
Particulate P	µg/l	184	78	7	5	3
Total P	µg/l	230	113	12	10	10
Turbidity	NTU	127	40.6	5.1	4.3	3.1
TSS	mg/l	110	20.0	1.6	1.5	1.4
BOD	mg/l	5.5	2.9	2.1	2.1	1.6
Sulfate	mg/l	3.9	15.3	49.6	65.3	76.3
Chloride	mg/l	92	93	101	100	102
Diss. Aluminum	mg/l	49	49	17	17	13
Total Coliform	No./100 ml	900	600	< 2	< 2	< 2
Fecal Coliform	No./100 ml	400	200	< 2	< 2	< 2
NaOH Buffer Added	mg/l	--	--	0.0	0.0	8.0

1. Measured pH values at 1 minute, 1 hour and 24 hours following chemical additions.

RESULTS OF LABORATORY JAR TESTS CONDUCTED ON STORMWATER RUNOFF SAMPLES COLLECTED FROM THE 42-INCH RCP ENTERING CLEAR LAKE ON MARCH 2, 1997

PARAMETER	UNITS	COMPOSITE RAW	SETTLED WITHOUT ALUM	ALUM TREATED AND SETTLED FOR 24 HOURS (Dose in mg/l as Al)		
				5 mg/l	7.5 mg/l	10 mg/l
pH (initial)	s.u.	7.64	7.64	7.64	7.64	7.64
pH (1 minute)[1]	s.u.	7.64	7.64	7.16	7.02	6.88
pH (1 hour)[1]	s.u.	7.60	7.61	7.12	6.97	6.86
pH (24 hours)[1]	s.u.	7.56	7.59	7.55	7.57	7.43
Conductivity	µmho/cm	22,041	21,181	22,471	22,364	22,794
Alkalinity	mg/l	262	234	227	219	213
NH_3-N	µg/l	567	350	472	459	493
NO_2 + NO_3-N	µg/l	1695	1576	1734	1722	1643
Diss. Organic N	µg/l	1265	1876	1289	1400	1789
Particulate N	µg/l	491	155	135	100	< 30
Total N	µg/l	4018	3957	3630	3681	3940
Diss. Ortho-P	µg/l	43	26	2	1	1
Particulate P	µg/l	47	13	5	3	3
Total P	µg/l	99	40	11	9	8
Turbidity	NTU	76.2	11.3	4.3	3.3	2.8
TSS	mg/l	19.0	16.4	3.4	2.3	2.1
BOD	mg/l	6.2	7.3	0.8	0.7	0.7
Sulfate	mg/l	133	131	155	200	213
Chloride	mg/l	8507	8937	8977	9157	9817
Diss. Aluminum	mg/l	34	49	39	104	43
Total Coliform	No./100 ml	150	140	3	< 2	< 2
Fecal Coliform	No./100 ml	120	130	2	< 2	< 2
Total Iron	µg/l	6	6	20	9	< 6
NaOH Buffer Added	mg/l	--	--	0.0	0.0	0.0

1. Measured pH values at 1 minute, 1 hour and 24 hours following chemical additions.

RESULTS OF LABORATORY JAR TESTS CONDUCTED ON STORMWATER RUNOFF SAMPLES COLLECTED FROM THE 42-INCH RCP ENTERING CLEAR LAKE ON MARCH 5, 1997

PARAMETER	UNITS	COMPOSITE RAW	SETTLED WITHOUT ALUM	ALUM TREATED AND SETTLED FOR 24 HOURS (Dose in mg/l as Al)		
				5 mg/l	7.5 mg/l	10 mg/l
pH (initial)	s.u.	7.50	7.50	7.50	7.50	7.50
pH (1 minute)[1]	s.u.	7.50	7.50	6.56	6.21	5.90
pH (1 hour)[1]	s.u.	7.46	7.47	6.56	6.29	6.01
pH (24 hours)[1]	s.u.	7.38	7.43	7.32	7.15	7.01
Conductivity	µmho/cm	1401	1392	1348	1362	1362
Alkalinity	mg/l	75.9	71.1	54.1	41.6	33.6
NH_3-N	µg/l	173	125	111	126	160
NO_2 + NO_3-N	µg/l	958	928	794	785	819
Diss. Organic N	µg/l	366	319	498	488	461
Particulate N	µg/l	2162	126	79	44	< 30
Total N	µg/l	3659	1498	1482	1443	1445
Diss. Ortho-P	µg/l	33	20	2	1	1
Particulate P	µg/l	193	128	10	8	7
Total P	µg/l	232	148	14	11	10
Turbidity	NTU	25.7	5.3	2.3	1.8	0.9
TSS	mg/l	16.2	12.1	2.1	1.2	0.7
BOD	mg/l	5.1	3.2	1.5	1.5	1.5
Sulfate	mg/l	25.1	21.8	46.4	68.3	71.8
Chloride	mg/l	264	300	279	287	293
Diss. Aluminum	mg/l	15	15	27	19	14
Total Coliform	No./100 ml	120	60	2	< 2	< 2
Fecal Coliform	No./100 ml	60	20	< 2	< 2	< 2
NaOH Buffer Added	mg/l	--	--	0.0	0.0	0.0

1. Measured pH values at 1 minute, 1 hour and 24 hours following chemical additions.

RESULTS OF LABORATORY JAR TESTS CONDUCTED ON STORMWATER RUNOFF SAMPLES COLLECTED FROM THE 42-INCH RCP ENTERING CLEAR LAKE ON MARCH 28-29, 1997

PARAMETER	UNITS	COMPOSITE RAW	SETTLED WITHOUT ALUM	ALUM TREATED AND SETTLED FOR 24 HOURS (Dose in mg/l as Al)		
				5 mg/l	7.5 mg/l	10 mg/l
pH (initial)	s.u.	7.32	7.32	7.32	7.32	7.32
pH (1 minute)[1]	s.u.	7.32	7.32	6.77	6.52	6.34
pH (1 hour)[1]	s.u.	7.46	7.45	6.77	6.57	6.42
pH (24 hours)[1]	s.u.	7.59	7.56	7.34	7.19	7.06
Conductivity	µmho/cm	1541	1608	1532	1540	1551
Alkalinity	mg/l	108	101	62.5	60.3	43.8
NH_3-N	µg/l	341	408	392	325	383
NO_2 + NO_3-N	µg/l	502	734	764	748	777
Diss. Organic N	µg/l	295	439	339	455	407
Particulate N	µg/l	6414	325	87	< 30	< 30
Total N	µg/l	7552	1906	1582	1543	1582
Diss. Ortho-P	µg/l	9	8	1	1	1
Particulate P	µg/l	750	43	11	4	4
Total P	µg/l	764	54	15	9	9
Turbidity	NTU	240	9.4	1.1	0.7	0.6
TSS	mg/l	498	17.0	4.8	3.5	2.8
BOD	mg/l	11.5	2.3	0.7	0.5	< 0.3
Sulfate	mg/l	35.5	30.5	61.6	83.2	103
Chloride	mg/l	388	345	332	407	377
Diss. Aluminum	mg/l	18	18	48	33	23
Total Coliform	No./100 ml	960	100	20	18	6
Fecal Coliform	No./100 ml	870	72	12	10	< 2
Total Iron	µg/l	20	11	6	14	< 6
NaOH Buffer Added	mg/l	--	--	0.0	0.0	0.0

1. Measured pH values at 1 minute, 1 hour and 24 hours following chemical additions.

RESULTS OF LABORATORY JAR TESTS CONDUCTED ON STORMWATER RUNOFF SAMPLES COLLECTED FROM THE 42-INCH RCP ENTERING CLEAR LAKE ON APRIL 5, 1997

PARAMETER	UNITS	COMPOSITE RAW	SETTLED WITHOUT ALUM	ALUM TREATED AND SETTLED FOR 24 HOURS (Dose in mg/l as Al)		
				5 mg/l	7.5 mg/l	10 mg/l
pH (initial)	s.u.	7.36	7.36	7.36	7.36	7.36
pH (1 minute)[1]	s.u.	7.36	7.36	6.61	6.34	6.04
pH (1 hour)[1]	s.u.	7.34	7.41	6.63	6.38	6.07
pH (24 hours)[1]	s.u.	7.32	7.46	7.66	7.61	7.29
Conductivity	µmho/cm	616	564	572	588	593
Alkalinity	mg/l	74.3	73.7	65.3	59.6	57.5
NH_3-N	µg/l	255	191	197	209	221
NO_2 + NO_3-N	µg/l	951	834	821	810	822
Diss. Organic N	µg/l	367	478	391	320	291
Particulate N	µg/l	1004	229	56	138	130
Total N	µg/l	2577	1732	1465	1477	1449
Diss. Ortho-P	µg/l	26	13	3	3	2
Particulate P	µg/l	176	43	10	8	4
Total P	µg/l	208	66	13	12	9
Turbidity	NTU	25.7	5.3	1.3	0.8	0.7
TSS	mg/l	61.0	11.0	2.1	1.5	0.9
BOD	mg/l	2.5	2.1	2.0	2.0	1.9
Sulfate	mg/l	20.5	22.5	49.4	62.7	67.4
Chloride	mg/l	76	91	79	83	84
Diss. Aluminum	mg/l	21	15	30	36	15
Total Coliform	No./100 ml	396	300	78	40	26
Fecal Coliform	No./100 ml	344	212	58	26	12
Total Iron	µg/l	6	14	< 6	20	13
NaOH Buffer Added	mg/l	--	--	0.0	0.0	0.0

1. Measured pH values at 1 minute, 1 hour and 24 hours following chemical additions.

APPENDIX C

RESULTS OF LABORATORY TESTING TO EVALUATE THE EFFECTIVENESS OF FERRIC CHLORIDE FOR TREATMENT OF STORMWATER RUNOFF ENTERING CLEAR LAKE

RESULTS OF LABORATORY JAR TESTS CONDUCTED ON STORMWATER RUNOFF SAMPLES COLLECTED FROM THE 42-INCH RCP ENTERING CLEAR LAKE ON MARCH 2, 1997

PARAMETER	UNITS	COMPOSITE RAW	SETTLED WITHOUT ALUM	IRON TREATED AND SETTLED FOR 24 HOURS (Dose in mg/l as Fe)		
				10 mg/l	15 mg/l	20 mg/l
pH (initial)	s.u.	7.64	7.64	7.64	7.64	7.64
pH (1 minute)[1]	s.u.	7.64	7.64	7.12	6.97	6.90
pH (1 hour)[1]	s.u.	7.60	7.61	7.09	6.90	6.76
pH (24 hours)[1]	s.u.	7.56	7.59	7.47	7.47	7.45
Conductivity	µmho/cm	22,041	21,181	22,256	21,934	22,901
Alkalinity	mg/l	262	234	216	221	210
NH_3-N	µg/l	567	350	476	481	475
NO_2 + NO_3-N	µg/l	1695	1576	1710	1727	1698
Diss. Organic N	µg/l	1265	1876	1384	1362	1510
Particulate N	µg/l	491	155	232	283	< 30
Total N	µg/l	4018	3957	3802	3853	3698
Diss. Ortho-P	µg/l	43	26	1	1	1
Particulate P	µg/l	47	13	5	6	2
Total P	µg/l	99	40	10	9	7
Turbidity	NTU	76.2	11.3	4.2	2.0	1.8
TSS	mg/l	19.0	16.4	25.1	24.1	21.2
BOD	mg/l	6.2	7.3	0.7	0.7	0.6
Sulfate	mg/l	133	131	149	154	189
Chloride	mg/l	8507	8937	8957	9397	9057
Diss. Aluminum	mg/l	34	49	46	44	47
Total Coliform	No./100 ml	150	140	4	< 2	< 2
Fecal Coliform	No./100 ml	120	130	< 2	< 2	< 2
Total Iron	µg/l	6	6	< 6	< 6	< 6
NaOH Buffer Added	mg/l	--	--	0.0	0.0	0.0

1. Measured pH values at 1 minute, 1 hour and 24 hours following chemical additions.

RESULTS OF LABORATORY JAR TESTS CONDUCTED ON STORMWATER RUNOFF SAMPLES COLLECTED FROM THE 42-INCH RCP ENTERING CLEAR LAKE ON MARCH 5, 1997

PARAMETER	UNITS	COMPOSITE RAW	SETTLED WITHOUT ALUM	IRON TREATED AND SETTLED FOR 24 HOURS (Dose in mg/l as Fe)		
				10 mg/l	15 mg/l	20 mg/l
pH (initial)	s.u.	7.50	7.50	7.50	7.50	7.50
pH (1 minute)[1]	s.u.	7.50	7.50	6.47	6.22	5.97
pH (1 hour)[1]	s.u.	7.46	7.47	6.55	6.24	5.99
pH (24 hours)[1]	s.u.	7.38	7.43	7.25	7.16	7.11
Conductivity	µmho/cm	1401	1392	1366	1376	1384
Alkalinity	mg/l	75.9	71.1	58.4	45.8	37.7
NH_3-N	µg/l	173	125	112	105	127
NO_2 + NO_3-N	µg/l	958	928	743	777	795
Diss. Organic N	µg/l	366	319	470	451	427
Particulate N	µg/l	2162	126	173	282	133
Total N	µg/l	3659	1498	1498	1615	1482
Diss. Ortho-P	µg/l	33	20	3	2	1
Particulate P	µg/l	193	128	12	9	7
Total P	µg/l	232	148	15	11	9
Turbidity	NTU	25.7	5.3	1.8	1.6	1.5
TSS	mg/l	16.2	12.1	2.2	1.5	1.0
BOD	mg/l	5.1	3.2	1.3	1.3	1.2
Sulfate	mg/l	25.1	21.8	24.7	23.8	25.3
Chloride	mg/l	264	300	318	316	353
Diss. Aluminum	mg/l	15	15	8	11	10
Total Coliform	No./100 ml	120	60	14	10	10
Fecal Coliform	No./100 ml	60	20	6	4	6
NaOH Buffer Added	mg/l	--	--	0.0	0.0	0.0

1. Measured pH values at 1 minute, 1 hour and 24 hours following chemical additions.

RESULTS OF LABORATORY JAR TESTS CONDUCTED ON STORMWATER RUNOFF SAMPLES COLLECTED FROM THE 42-INCH RCP ENTERING CLEAR LAKE ON MARCH 28-29, 1997

PARAMETER	UNITS	COMPOSITE RAW	SETTLED WITHOUT ALUM	IRON TREATED AND SETTLED FOR 24 HOURS (Dose in mg/l as Fe)		
				10 mg/l	15 mg/l	20 mg/l
pH (initial)	s.u.	7.32	7.32	7.32	7.32	7.32
pH (1 minute)[1]	s.u.	7.32	7.32	6.71	6.53	6.36
pH (1 hour)[1]	s.u.	7.46	7.45	6.71	6.57	6.42
pH (24 hours)[1]	s.u.	7.59	7.56	7.30	7.16	7.09
Conductivity	µmho/cm	1541	1608	1551	1579	1604
Alkalinity	mg/l	108	101	70.3	57.0	43.0
NH_3-N	µg/l	341	408	290	354	334
NO_2 + NO_3-N	µg/l	502	734	781	792	764
Diss. Organic N	µg/l	295	439	432	302	381
Particulate N	µg/l	6414	325	181	292	119
Total N	µg/l	7552	1906	1684	1740	1598
Diss. Ortho-P	µg/l	9	8	1	1	1
Particulate P	µg/l	750	43	4	5	2
Total P	µg/l	764	54	9	8	6
Turbidity	NTU	240	9.4	1.1	2.2	1.5
TSS	mg/l	498	17.0	4.5	3.5	3.3
BOD	mg/l	11.5	2.3	0.7	0.3	< 0.3
Sulfate	mg/l	35.5	30.5	33.8	34.0	31.7
Chloride	mg/l	388	345	270	307	325
Diss. Aluminum	mg/l	18	18	12	9	13
Total Coliform	No./100 ml	960	100	12	10	2
Fecal Coliform	No./100 ml	870	72	6	6	< 2
Total Iron	µg/l	20	11	20	< 6	87
NaOH Buffer Added	mg/l	--	--	0.0	0.0	0.0

1. Measured pH values at 1 minute, 1 hour and 24 hours following chemical additions.

RESULTS OF LABORATORY JAR TESTS CONDUCTED ON STORMWATER RUNOFF SAMPLES COLLECTED FROM THE 42-INCH RCP ENTERING CLEAR LAKE ON APRIL 5, 1997

PARAMETER	UNITS	COMPOSITE RAW	SETTLED WITHOUT ALUM	IRON TREATED AND SETTLED FOR 24 HOURS (Dose in mg/l as Fe)		
				10 mg/l	15 mg/l	20 mg/l
pH (initial)	s.u.	7.36	7.36	7.36	7.36	7.36
pH (1 minute)[1]	s.u.	7.36	7.36	6.58	6.34	6.03
pH (1 hour)[1]	s.u.	7.34	7.41	6.61	6.38	6.04
pH (24 hours)[1]	s.u.	7.32	7.46	7.62	7.47	7.21
Conductivity	µmho/cm	616	564	584	593	617
Alkalinity	mg/l	74.3	73.7	81.9	72.8	66.4
NH_3-N	µg/l	255	191	168	167	193
NO_2 + NO_3-N	µg/l	951	834	834	815	820
Diss. Organic N	µg/l	367	478	345	388	357
Particulate N	µg/l	1004	229	361	505	417
Total N	µg/l	2577	1732	1708	1875	1787
Diss. Ortho-P	µg/l	26	13	2	2	2
Particulate P	µg/l	176	43	4	5	4
Total P	µg/l	208	66	11	9	8
Turbidity	NTU	25.7	5.3	1.8	1.8	1.6
TSS	mg/l	61.0	11.0	2.2	1.8	1.6
BOD	mg/l	2.5	2.1	1.8	1.8	2.0
Sulfate	mg/l	20.5	22.5	22.4	21.1	22.0
Chloride	mg/l	76	91	83	81	86
Diss. Aluminum	mg/l	21	15	6	15	9
Total Coliform	No./100 ml	396	300	164	184	150
Fecal Coliform	No./100 ml	344	212	120	164	132
Total Iron	µg/l	6	14	11	20	6
NaOH Buffer Added	mg/l	--	--	0.0	0.0	0.0

1. Measured pH values at 1 minute, 1 hour and 24 hours following chemical additions.